

# GREEN PAPER



Picture: Jens Lyncker Fotografie  
Diakonie Hospital Stuttgart

## Why is AIR-to-WATER RATIO on Green Roofs so important?

The air-to-water ratio is the ratio between air and water in the pores of a media.

*By Green Roof Expert Extraordinaire Jorg Breuning, March 2020*

### Introduction (Challenges)

On ground disconnected structures like roofs the available rooting space for plants is typically limited because of weight restraints. Additionally the Green Roof components and the plants are exposed to more extreme environmental impact like higher wind speeds, reflecting surfaces, higher temperatures, air pollution, artificial light at night, lower bio-diversity and more. In such locations the Air-to-Water ratio within the Green Roof system can fluctuate much more often beyond the desired range what causes stress on the plants and stress on beneficial microbes.

If more extremes are expected, selecting the right plants and right Green Roof system is crucial. In some cases an irrigation system (temporary or permanent) or enhanced drainage system should be considered to reduce stress conditions on the plants and to improve soil biology. However, operating an inappropriate irrigation system (like sprinklers) or drainage systems that were never engineered specifically for Green Roof applications can be counterproductive because the Air-to-Water ratio is not considered. Constant adverse Air-to-Water ratio is the problem on over 60% of the Green Roofs in North America and with changing weather patterns this problem is getting worse.



## What is AIR-to-WATER RATIO (Introduction)

The vast majority of plants used on extensive or intensive Green Roofs thrive best within a specific Air-to-Water ratio range in the root zone of a Green Roof system. Over the course of a year and depending on weather conditions, a Green Roof system's desirable the Air-to-Water ratio shall vary between 35/65 to 65/35 (65% water/35% air to vice versa). An Air-to-Water ratio in such a range is important for the resilience of plants, for nutrient exchange capacity, pH buffering capability, and beneficial (aerobe) microbes. Peaks in one or the other direction (adverse Air-to-Water ratio) can be tolerated by the plants if this is temporary and very limited in time.

To successfully reduce adverse Air-to-Water ratio it takes, extensive experience, profound horticultural knowledge, understanding the historic developments, seeing environmental/natural facts, and the ability to evaluate natural indicators on existing Green Roofs.



Left in picture:  
Root growth on Green Roof systems with balanced Air-to-Water ratio.

Right in picture:  
Root growth on Green Roof systems with adverse Air-to-Water ratio (waterlogging materials).

## Understanding Green Roof Systems

As long as humans have cultivated plants they have learned that natural parameters in biology, physics and chemistry are given and everything has to collaborate within these nature's laws. Although we are able to Gen-manipulate plants for better yield, more pest resistant, and for more stress resistance, but the nature's laws won't change.

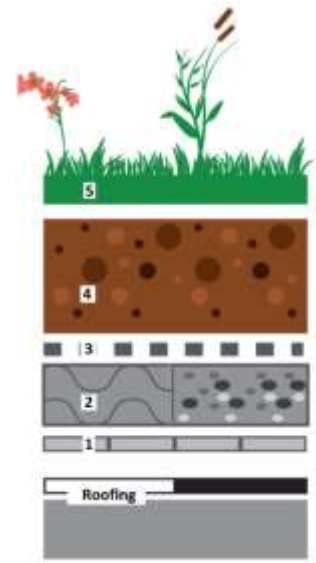
An increasingly number of stormwater professionals recognize that Green Roofs are an excellent, the least expensive and most natural stormwater management tool with many added values for the environment we live in. However, as often we talk about Green Roofs as often these specialized professionals forget about the Quarterbacks or key players of such systems: the plants!


It is a simple fact that the more we do for healthy plants with a natural diversity, the better a Green Roof system can retain and detain stormwater.

Within the development of modern Green Roof technology over the last 50 years most Green Roof systems are built with different continuous layers.

The basic layers are (from roofing up):

1. Protection layer to separate between roofing and green roofing trade and to protect the underlying components.
2. Soil/Media extension layer (often described as drainage layer) to mimic natural soil profiles and avoid anaerobic conditions in the rooting zone.
3. Filter layer that avoids fine particle migration within the system.
4. Engineered Growth Media or soil that meets parameters of FLL\*.
5. Vegetation.



 Trays, pre-planted containers or modular systems try to mimic the same layers within a small defined area like a plastic box, metal container or soil filled bags. These systems are solely made for easy shipping which is blink of eye in the life span of a Green Roof. These systems are not continuously installed and so these systems are considered as a temporary solution for a limited time (5-8 years). In most cases these planters or trays are getting re-planted or removed over time, many already ended up on landfills.

### Understanding Green Roof Plants

Because of the highly fluctuating Air-to-Water ratio, experienced Green Roof designers prefer utilizing hardy plants. Ideally plants that can cope with no irrigation, that are more resistant to drought and temporary extensive water, that are more heat and wind tolerant, and vegetation that can fast regenerate after stress.

In most cases and on shallow extensive Green Roofs succulent type of plants (like Sedums) are often the preferred and common choices. Even so the Sedum family is very large, colorful and low growing, for enhanced resilience they also rely on competition with other plant species like mosses, perennials or grasses of comparable hardy properties. Horticultural experts call this “natural plant diversity”. Such natural plant diversity stands in a full contrast to Sedum monocultures that often come with tray (modular) systems or systems with pre-vegetated mats. Pre-cultivated systems are very popular in North America where instant gratification and more revenue play a pivot role.

The variety of different plant families or allowing a natural diversity increases root activity within the Green Roof system, creates healthy rooting space, soil structure and texture, with desired micro and macro pores for enhanced soil biology, all resulting into a more ideal Air-to-Water ratio, better water retention and increasing stormwater detention.

## Understanding the Current Green Roof Industry

With the focus and current trend on stormwater management, it is “natural” that many people try to improve the stormwater managing ability of Green Roofs. In this regard the Green Roof industry is not getting tired in developing a deluge of products and components that are supposed to help with stormwater management, stormwater retention, stormwater detention, stormwater neutralization, and stormwater clarification. Unfortunately most of them are forgetting about the champions; the Plants!

Interestingly many of these innovators are often highly decorated with desirable titles, have done a lot of commercial reductionist research, micro- and selective-research over a short time with floods of data, have written a lot papers that are piling up in the cloud, and they have introduced new words or terms that sound fancy, makes them look trendy or educated.

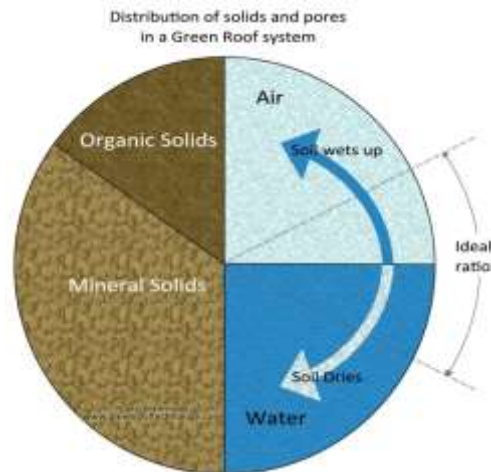
## Learn From Common Sense

Our ancestors preferred Green Roofs as an extension of living green and private recreational space, for growing supplemental food or for building protective purposes. Today’s trend moves away from insulating purposes (because that was wrong in the first place) to stormwater management. Environmental aspects go under in the craving for a Return-of-Investment (ROI). With an entire Armada of specialty Green Roof products, with an army of engineers, and a deluge of data people are trying to narrow-down a living machine (a.k.a. Green Roof) into a static, man-made tool by altering, avoiding or eliminating natural processes which are elementary for healthy and resilient survival of plants/vegetation. It is like feeding less to livestock to reduce Methane gas emissions.

Some of the problematic and counterproductive specialty Green Roof products are:

- ❗ Very thick layers of synthetic fabrics with increased retention and/or detention capacity based on internal capillarity properties or hydrophilic properties. These specialty fabrics often reverse natural capillarity of engineered soils what dries out the soils faster or when infiltrated with organics particles there is waterlogging and rotting.
- ❗ Some Retention and Detention/Drainage Boards (mainly made from plastic) have no time-release overflow or no overflow that allows air between the water reservoirs. Not talking about polystyrene plastics that are bad for the environment in all regards.
- ❗ Water Crystals, Hydrogels are small chunks (or crystals) of man-made, water-absorbing polymers. The chunks are like sponges – they hold a tremendous amount of water by increasing in size. The liquid is then supposed to release gradually into the soil. These products have a limited lifespan that is generally less than 1/10 the lifetime of a Green Roof and so not worth the investment.
- ❗ Mineral Wool is a manmade material from glass fibers either spun together or adhered together. Beside that mineral fibers are a possible human carcinogen these specialty products support an Air-to-Water ratio from 95/5 to 5/95 (95% water/5% air to vice versa) whereas the strong water holding capacity /waterlogging is much longer than in natural soil profiles and creates temporary anaerobe conditions = water stress on succulent type plants and root rot.

- ❗ High organic content (over 50%) in growth media (soil). Decomposing of organic matter increases biology activity which is related to heat, causes unusual nutrient increase or decrease, and an increase of carbon dioxide in the soil profile. This and the additional risk of waterlogging increase the stress on plants.
- ❗ Slow release or fast release, solid or liquid fertilizers of synthetic/chemical origin behave on extreme locations like roofs very different to on-grade applications. Especially in combination with the above specialty products there could be a serious and snowballing risk for the vegetation and the environment through run-off. It can increase salt concentrations or chemical process that cause deterioration of other components (e.g. roofing) of the Green Roof or the structure.
- ❗ Chemical weeding is a common practice mostly used in North America where environmental laws and standards are very low. Chemical on extremes locations behave very different to on-grade locations and succulent type of plants that have a slower metabolism what means they might die very slowly. What looks like chemical “resident” may be affect such plants years later, weakens them and exposes them to other diseases easier.



## Conclusion

Vegetation placed on ground remote or ground disconnected location is a century-old tradition for very different and combined purposes. Optimizing only the aspect “stormwater” will ultimately affect all other natural cycles within a Green Roof system. Especially in North America these considerations for natural cycles on a Green Roof are often not known, disregarded or purposeful ignored for a desperate craving of profit and ROI.

This might look like a society accepted approach but it can result that Green Roofs in North America might not get as popular and as accepted as in European countries where commonsense, decades of monitoring, fundamental education, and solid experience is the driver for their success. Most countries in Europe understand that healthy driven plants, plant diversities and plant communities on roofs increase the benefits as they progress, develop, and generate a natural ecosystem.

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