ALPHA SPACE - WHERE PLANTS FLY BEYOND THE VERTICAL GARDEN

Lloyd Godman[1], John Power[2], Stuart Jones[3], and Grant Harris[4]

FROM PHOTOGRAPHY TO PHOTOSYNTHESIS

In 1996, my interests as a passionate gardener and photo-based artist, that both dated from the 1970s, collided when I made the connection that plants are actually a form of photography; (photography from the Greek - meaning light drawing). Both photography and plants use the magical, mysterious ingredient that is LIGHT and the essential force that drives life on the planet.

In fact, the largest photosensitive emulsion we know of is the planet earth. I draw inspiration and endless fascination from the awareness that the earth rotates in space and orbits the sun at a precise distance for the sun's radiation to affect the elegant process of photosynthesis through the myriad of plants that have evolved and grow on the planet. The earth is a three dimensional living photograph. The atmosphere and biosphere are also key factors that mediate the harshness of radiation bombarding the earth and nurture life on the planet that we know and depend upon. The process is an amazing thing and something we should revere and protect. Imagine the earth as a basket ball, wrapped in the thinnest paper you could find. The thickness of this delicate paper is equivalent to the atmosphere, and the depth of the paper's texture is thicker than the tallest trees, even thicker than the tallest high rise buildings!

Image sequences from NASSA shows how vegetation grows, dies back, changes colour with the seasons, how the "photographic image" that is our planet alters. Increasingly human intervention plays a larger role in transforming the image of the globe we inhabit. Imagine foliated land as a photo-sensor (like in a digital camera)

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1. MFA : Ecological artist is one of a new breed of environmental artists whose work is directly influencing 'green' building design. … Godman's installations are the result of a unique blend of botanical science, environmental awareness and artistic expression. All three elements are intrinsic to the practical realisation of his polymathic vision." www.lloydgodman.net. Lloydgodman@gmail.com 001161448188899
2. Editor of *Facility Management Magazine* Aug. 2011
3. Structural Engineer BE(Civil & Computing), FIEAust, CPEng, NPER. Stuart Jones has recently been appointed Technical Director for Hyder Consulting in Melbourne. Previous to this he was the Owner/Director of Point 5 Consulting in Melbourne for 14 years. Stuart has over 25 years professional experience in all phases of project delivery and specialises in creative structural design with extensive experience in Australia and throughout Asia.
4. Environmental Scientist and Arboricultural Consultant. Grant Harris is the principle of Ironbark Environmental Arboriculture, with over 12 years experience in the arboricultural sector he also holds a degree in Environmental Science (Wildlife and Conservation Biology). His particular areas of interest are the use of green infrastructure to mitigate urban heat island effects and urban ecology.

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that responds to light speeding past the planet. Plants continually use this energy source to perform a complex series of functions that mediate the climate and atmosphere in a positive manner for thousands of species, including humans.

THE URBAN HABITAT

When we remove vegetation and replace it with buildings and urban infrastructure like roads and car parks, as in our cities, the materiality of the building becomes a "dead pixel" in the living sensor of the planet. The images from satellites also show unmistakable patterns of deforestation of not only the expansion of the urban environment, but the resources needed to sustain it, like logging, rural agriculture and mining. The green fabric that clothes the earth is fraying. Sadly through over use the garment we depend upon is wearing out, a brand new covering appears unavailable and repairing the old one by stitching plants into the structures of our cites is the decisive option.

Envisage plants in continual conflict with the geology of the planet. For millions of years they have employed an innate compulsion to cover geology with a green living membrane that supports other life. However, over millennium, natural process like storms, floods, volcanoes, erosion, desertification and fire tear at the green fabric revealing the underlying geology; but plants fight back in a continual process.

While this modus operandi of covering, exposing and covering again has always found balance and may not have been an issue for thousands of years, the scale to which our cities have exponentially expanded in recent times demands that we now consider, plan and act to integrate cites, including the tallest buildings, into the biosphere of the planet. The combined surface of high-rise buildings can provide significant areas to support plants, to weave back the green fabric. Buildings and urban infrastructure have the potential to become support structures for plants and we see this with the expansion of roof and vertical gardens.

We know that integrating plants into the built environment, improves air quality, moderates temperature, improves human wellbeing, lifts the spirit and can provide habitats for other species. In March 2015, it was promising to see a law passed in France which mandates rooftops on new buildings built in commercial zones must either be partially covered in plants or solar panels. But how can this work in practice? Present vertical garden systems have limitations, can be expensive, require energy, use depleting phosphorus supplies and demand constant maintenance, so as a compliment we need to develop other systems for more demanding situations like high-rise development, we need to explore "extreme gardening".

BEGINNINGS

From the conceptual intersection of photography and photosynthesis, in 1996, I began by growing images into the leaves of wide leaved Bromeliad plants. Later, I engaged in a series of installations with Bromeliad plants in coal burning boiler houses (plant rooms - playing with ideas of the epiphyte and the parasite) and other locations including elevators. Quickly the

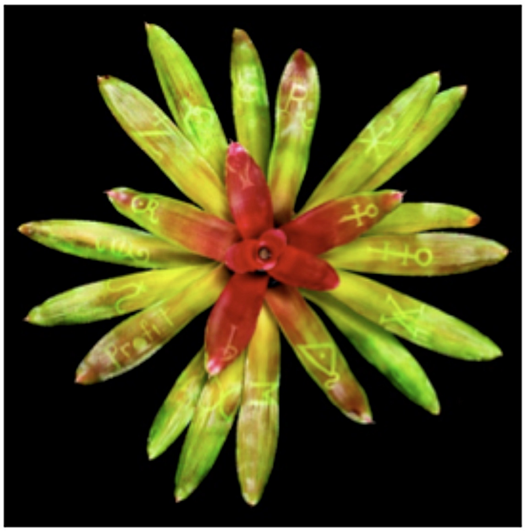


FIGURE 1: *Cause and effect* - Various Alchemic symbols - 1996 - A photosynthetic image grown into the tissue of a Bromeliad plant.

FIGURE 2: *enLIGHTen* projection installation - Temple Gallery Dunedin New Zealand - Lloyd Godman 1999 - an interactive installation with seven infrared activated projectors and suspended Bromeliad plants that throw shadows onto the large (7.5m long x 3.5m high) tissue paper screens.

work evolved into complex, interactive light installations of Bromeliads suspended from the ceiling of art galleries.

At this time I lived very close to the ocean in Dunedin, New Zealand, and developed a suspended vertical garden of Bromeliads in the entrance to my house that did not need reticulated water. I grew some Tillandsias in trees in my garden where I learned certain species were tolerant of cold salt winds. Through studying the unique biology of these amazing plants and experimentation, I came to realize how they could not only adapt to the harsh conditions of an art gallery's air con system, but to the extreme climate at the top of Melbourne's Eureka Tower at level 92. I came to realize that using living plants in or as art, transcends art as environmental comment and becomes art as an environmental action. In this I was inspired by Joseph Beuys's "7000 Oaks – City Forestation Instead of City Administration", 1982[1] and set about to explore *art as active solution*.

BIOLOGY OF BROMELIADS

Bromeliads are a recent addition to the plant kingdom and have displayed a tendency to evolve as xerophytes and epiphytes; that is they thrive in dry conditions and grow on other plants, rocks or some other support system. In doing this they have developed several sophisticated biological systems that make them ideal for incorporating into the urban environment. An analogy we might draw with their biology, is they are like driving a modern car compared to a vehicle from the 1950s with more ancient plant families. When we talk of Bromeliads, we mean a family of plants totalling more than 3,000 species across more than 50 genera of which Tillandsias are but one genus. The diversity of plants within the family grow from humid tropical areas on the coast to dry harsh environments many thousands of metres up on vertical cliff faces. Some genus and specific species of plants have developed special biological systems to greater degrees than others, so it is important to understand that not all plants within the family or a genus will thrive in every situation.

TRICHOMES

Bromeliad leaves have a covering of tiny cells called trichomes that allow the plant to up take water through this cell into the internal tissue. The familiar pineapple is a Bromeliad and the small silver cells seen on the leaf are trichomes. The most extreme example of trichome development is seen in Tillandsias or 'air plants', which in many species have completely discarded roots as a means of nutrient and water absorption relying entirely on leaf intake through the trichomes. The tiny cell is like a bowl which in this form closes the pores that absorb the water. When any moisture hits the cell it opens instantaneously to a plate shape, the pore openings are released and the moisture is channelled into the plant. As it dries the plate returns to a bowl and locks in the gained water. Some species are so efficient in this process that they can enact it just through differences between the internal humidity of the plant and the humidity of the atmosphere. In fact there are some Tillandsia that grow in areas where it has not rained for decades. As well as absorbing water and nutrients, they can also take in heavy metals from the atmosphere through the leaf and have been used in urban environments as biomonitors to track pollution levels. Biologist David Benzing, who wrote the Biology of Bromeliads and has been a supporter and consultant in our work with Bromeliads, carried out biomonitor experiments with Tillandsia on highways in Florida to gauge lead levels in the 1980s.[2] Since then Tillandsia have been used in other countries to track pollution levels.

Tillandsias can also offer a means of heat mitigation within the urban environment. The trichome is seen as a silver cell and is also a great reflector of radiation; in some species the cell can reflect 93% of the radiation falling on it.

FIGURE 3: A Tillandsia forming a flower - the silver Trichomes can be seen on the leaf and the colourful inflorescence.

FIGURE 4: An extreme close up of the silver Tricome cells that form even on the flower bracts of a Tillandsia.

CAM CYCLE

The other biological trick Bromeliads and some other plants like succulents, cacti and some orchids have evolved is a CAM cycle (crassulacean acid metabolism), whereby they grow at night. This is a reason succulents and cacti work well on many roof gardens where they are subjected to harsh daytime conditions. All plants have a stomata which takes in CO^2 and releases oxygen, however as a by-product of this purifying gas exchange, moisture is transpired from the plant tissue into the atmosphere. Most plants have this cell open during the day and consequently, on a hot, windy day the plant may not be able take enough water through the root system to maintain the required transpiration at the leaf, the foliage dehydrates and in extreme situations dies. However by using a CAM cycle, the stomata is closed during the heat of the day and only opens at night when there is less heat and radiation from the sun. This means that unlike most plants, CAM cycle plants capture carbon and produce oxygen at night; in the process they are very efficient at water retention. Pollution levels in cites peak in the evening with the return commute and plants fail to uptake CO^2, so CAM plants can offer a great contribution in maintaining urban air through a 24 hour cycle.

EXPERIMENTS IN MELBOURNE, AUSTRALIA

In 2005 I moved to Melbourne and once again began collecting and experimenting with Bromeliads in a quite different environment. While it took years to re-establish my collection, I directed more of my experiments to xerophitic Tillandsias which were drought and heat tolerant. At the Baldessin Press where I live, about 40km north-east of Melbourne, I created modest plant sculptures which are suspended in the air between buildings and trees adorned with Tillandsia, like the first version of “Entropy Spiral”, 2008. These works have largely been left to their own devices to grow over several years. The “Entropy Spiral” work has constantly endured hot periods up to 46 degrees Celsius and long periods of little moisture, but thrived while demanding no maintenance for 7 years.

In early 2010 the first suspended rotating air plant sculptures were developed. These were simple structures utilizing recycled bicycle wheels embellished with Tillandsias suspended on swivels that rotated on the breeze casting animated shadows onto the ground. From this success, I was inspired to experiment further with these living plant sculptures, to bring them into the public domain in urban environments.

FIGURE 5: *Entropy Spiral*, suspended living plant work, Baldessin Studio 2011.

FIGURE 6: *Entropy Rotation I* - Rotating suspended Tillandsia plant work -Private garden - 2011.

FIGURE 7: Time exposure of *Nature Reclaims the Helix*, Rotating suspended at the Baldessin Press 2011.

CH2 BUILDING EXPERIMENT

In terms of sustainability Melbourne City Council are aware of the need to create a sustainable city, in some areas they lead Australia. One of the cities proactive developments I was interested in was the new green CH2 building the council had completed which was promoted as a great example of cutting edge green architecture.

In 2011 I engaged in an experiment with Ralph Webster, Senior Architect with Melbourne City Council on the new CH2 building located at 240 Little Collins Street, Melbourne. CH2 was designed as a green building to not only conserve energy and water, but improve the wellbeing of its occupants through the quality of the internal environment of the building. Since its completion in 2006, climbing plants had been planted in water fed boxes on the north side of the building with the intention of growing them up metal netting. However the aspect is subject to very hot dry winds and the narrow alley way acts as a wind tunnel, extenuating the effect, which was drying out the plants and killing them.

Ralph mentioned the problem of growing plants in this location and I suggested mounting a hardy Tillandsia in the netting with no soil or water and simply leave the plant to its own devices as an experiment. The plant was left in this situation for 18 months and checked several times to prove that while they grew slowly they were thriving with no soil or reticulated watering system, whereas the climbing plants continued to struggle. While Ralph moved from his position at the council and this experiment was not followed after his departure, the experiment did lay the way for a larger project with City of Melbourne - ***"Airborne"***. In February 2015, I returned to check if the Tillandsia was still in place on the CH2 building, but it had disappeared. The climbing plants were still in place but covered much less of the netting than in 2011, suggesting the effort to replant and maintain them exceeded the ESD reward.

FIGURE 8: CH2 building North façade 2011. The location of the Tillandsia is marked with the red circle. Note the inconsistent growth of the climbing pants.

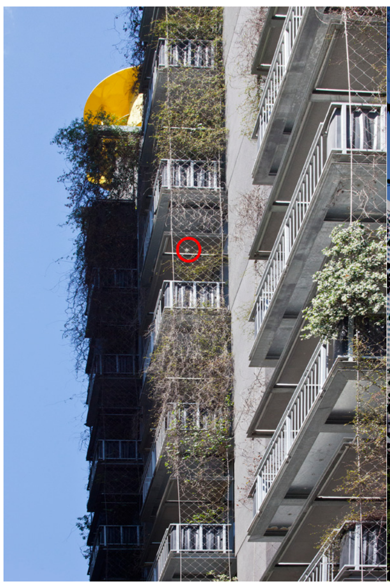
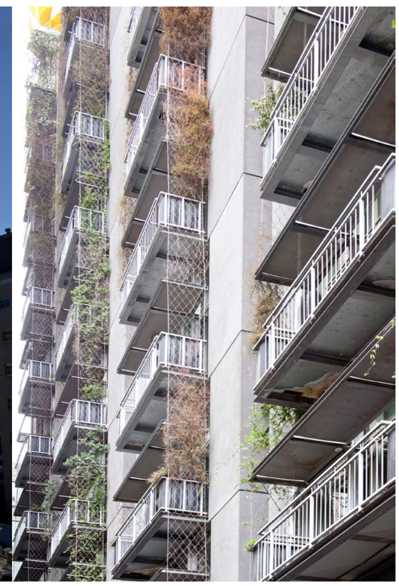


FIGURE 9: Detail of Tillandsia CH2 building North façade 2011.

FIGURE 10: North façade February 2015 shows the climbers with less growth than in 2011.



GROWING LIVING ART WITH A TEAM

Collaborating with writer Matt Blackwood, in 2012, we submitted a proposal for a permanent living Tillandsia interactive art work through City of Melbourne Arts which was short listed for the $360,000 project. While the project was not selected for the commission, the preparation of the proposal put me in touch with structural engineer Stuart Jones of Point 5 Consulting, who inspired by the potential joined the team offering great support and making a significant contribution in the past few years. For Stuart,

> "the two big advantages of air plants are their light weight and their suitability in different visual layers. For instance the façade at Federation Square, Melbourne, is a mixture of stone an metals. Just as zinc weathers or deteriorates over time, these plants do the inverse of this and grow a new resource over time. The ability to layer them is wonderful - they don't have to be a single layer. Façades can be built up from a number of different layers and those living layers can be turned on or off, one passive the other active as needed. Also the interface from the inside to outside can be important and these plants used in screens can allow effective ways to purge the heat from a building at night. The other exciting aspect is that you can create depth on a building façade it does not have to be a flat surface."

At this time Grant Harris also joined the team, he is an environmental scientist and arboricultural consultant. Before working as a consultant Grant was a climbing arborist, having climbed the tallest trees in the world, constructed platforms in the jungle for scientists and film crews to work from, Grant has a wealth of climbing and rigging skills which he has employed to install air plant sculptures for various exhibitions. For Grant,

> "From my experience of working as an arboricultural consultant in the urban forest I have a keen understanding of the critical importance of selecting the correct tree species for planting in a particular location. The same process of selecting appropriate plants needs to be applied to green walls and roofs to ensure these projects succeed in providing the environmental and aesthetic benefits which they promise. Through his years of experimentation, Lloyd Godman has demonstrated that Tillandsias are superbly adapted for use on urban façades; with extreme drought resistance and no requirement for soil they are perfectly suited for applications on tall buildings. In future years I hope to see the achievement of Godman's vision of a fully sustainable and truly 'green' green wall."

FIGURE 11: *Expanding dimension cube* - Camberwell Grammar School, Melbourne - May 2011 - Tillandsia plants, stainless steel, steel.

FIGURE 12: *Atmocycle I* - Installed at The Incinerator Gallery, Moonee Valley, Melbourne - May 2012.

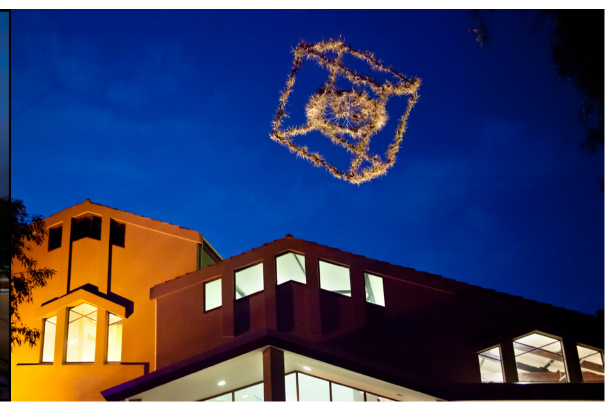


FIGURE 13: *Atmocycle - I* Installed at Yering Station, Victoria for the 2012 Yering Station Sculpture Exhibition and Awards.

FIGURE 14: Lloyd Godman with a Tillandsia wheel. Photograph Silvi Glattauer.

Since this time, Grant and Stuart, contributed and helped with a range of experiments and art exhibition installations of these living plant works. So in the following text, when I refer to "us", I mean Stu, Grant and myself.

AIRBORNE - THE ACID TEST

Supported through a City of Melbourne Arts Grants 2013, Airborne was an important test for the Tillandsias where air plant sculptures were installed for 13 months in central Melbourne with no soil or auxiliary watering system in a demanding location. The installation was to have a limited install life and to be removed by the end of 2013, but because the site was on Vic Rail land we gained an extension to leave the works installed for a few extra months. This allowed us to have the works in situ for more than a year as a trial through all seasons.

The location was beside a busy rail line at Flinders St Station, at Les Erdi Plaza, Northbank, Melbourne. The work consisted of eight suspended rotating air plant sculptures and withstood prolonged periods of dry including record heat (five consecutive days over 41 degrees Celsius). Despite the conditions, the plants grew, flowered, and reinforced the concept of a new space plants could occupy in the built environment beyond the roof top, beyond the vertical garden in what we termed Alpha Space. At home, honey eating birds like the Eastern Spine Bill, honey bees and other small insects frequent the flowers so it was not surprising that some of the flowers set seed. Praying mantis seed casings had also been laid on some leaves, which was evidence that even in this central city location, other species were benefiting from the installation of the plants.

The eight works were suspended between lighting posts along the rail corridor where the diesel trains leave Flinders St Station. There are eight metres between each post so the works spread out for 64 metres. When the trains depart the nearest platform, there is a loud roar of the engine with large clouds of black diesel fumes as the train engages with its load; so it was no surprise that when the works were removed, the Tillandsias on the work closest to where the trains leave from were covered in black particles. The particulates became less obvious on the plants as the distance away from the platform increased. However the particulates did not appear to hinder the growth of the plants. While the plants for the installation were hardened off before the install, after 13 months the growth habit of the plants had changed to a much more compact structure with shorter harder leaves. However the plants produced about seven or eight pups (vegetatively produced new plantlets) per plant, many more than one might see in a less stressful location where pup production might be two or three. We attribute the prolific pup production to the plants biological insurance - if one or more pups die then the plant has more reserves growing shoots to prosper from. Of several thousand individual Tillandsia used on the eight sculptures, only two plants had died during the 13 month install. It is difficult to ascertain the exact cause.

During the installation period, the living sculptures experienced strong winds of up to 115 kilometres per hour in a storm that ripped a large sculpture of a dog from its mounts but a few hundred meters away and brought down a brick wall that tragically killed three people in Melbourne city. As the suspended works are able to rotate on swivels they can dissipate the energy and do not become excited as a sail might.

FIGURE 15: *Atmocycle I* - *Airborne* project - Les Erdi Plaza, Northbank, February 2013, with Melbourne's tallest building Eureka tower in the background.

FIGURE 16: Time exposure of *Atmocycle I* - *Airborne* project. Supported as a temporary art installation by the City of Melbourne, through the Arts Grants Program - the work was installed for 13 months and removed early 2014.

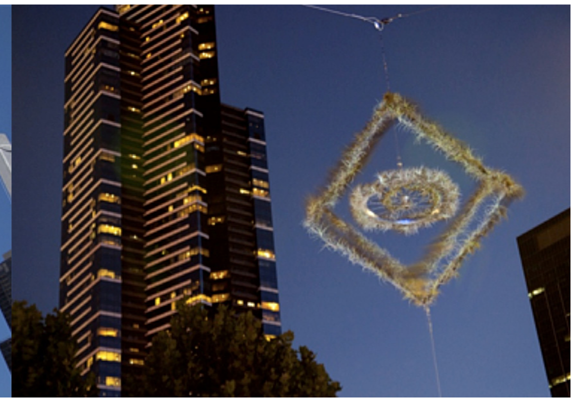


FIGURE 17: *Double Pyramid* - *Airborne* project - Les Erdi Plaza, Northbank, Melbourne.

FIGURE 18: *Expanding Dimension* - *Airborne* project - Les Erdi Plaza, Northbank, Melbourne.

FIGURE 19: *Nature Reclaims the Helix* - *Airborne* project - Les Erdi Plaza, Northbank, Melbourne.

FIGURE 20: *Time exposure of Atmocycle II* - *Airborne* project - Les Erdi Plaza, Northbank.

FIGURE 21: *Alpha Space Station I - Airborne* project - Les Erdi Plaza, Northbank, Melbourne.

FIGURE 22: *Time exposure of Alpha Space Station I -* rotating - *Airborne* project - Les Erdi Plaza, Northbank, Melbourne.

FIGURE 23: *Alpha Space Station II - Airborne* project - Les Erdi Plaza, Northbank, Melbourne.

FIGURE 24: *Time exposure of Alpha Space Station II -* rotating - *Airborne* project - Les Erdi Plaza, Northbank, Melbourne.

FIGURE 25: May 30 - 2013 flowering Tillandsias - *Airborne* project.

FIGURE 26: *Atmocycle II* foreground. Expanding Dimension background - *Airborne* project - Les Erdi Plaza, Northbank.

EXTREME GARDENING

Buildings within the urban environment are essentially refined geology, concrete, steel, glass etc. and when endeavouring to integrate plants into high-rise buildings, the lesson is to observe pioneer plants that first inhabit similar hostile environments. In effect, high vertical cliffs of rock with no humus, often little water and extreme temperatures; the type of environment some Tillandsia thrive in. As vegetal gardens, like the world's tallest vertical garden at 33 stories on One Park building in Sydney attempt to reach higher levels on façades, it becomes obvious that with height, conditions change and the climatic demands on plants increase. With current vertical gardens, there is an explicable enthusiasm to include a diverse range of species. The reality is that plants that succeed up to level ten might be stressed at level 20, struggle at level 40 and die at level 80 so the façade has multiple climate zones.

In nature we see far less diversity of species at higher altitudes and embedding plants on super high buildings presents a similar environment where hot dry winds might often reach over 200km/h. With reticulated irrigation systems no matter how much water is pumped through the root system, some plants are simply not able to uptake water at the rate of transpiration. Although extreme high temperature conditions might only last a few days a year, this can be devastating to these wall and roof gardens. Another factor that has to be considered is that with climate change and predicted increasing extreme weather, plants that succeed in one location might not in twenty years or even ten years time.

Most often the shape, texture and colour of a plants leaf gives an indication to the habitat it grows well in as does the way it sits to direct sunlight. Wide, flat, luxuriously green leaved plants tend to grow quickly in stable climates where the conditions are less stressful and they are not subjected to harsh, hot drying winds. By contrast Tillandsia grow slowly, with arching leaves that tend to have a strong concave cross-sectional form. This double curvature assure only small areas of the leaf are exposed to direct sun for short periods, reducing risk of over exposure to harmful radiation and burning. This natural design makes them ideal for many super high-rise building locations and hot façades. The options for planting high wall gardens in the humid tropics diminish as the climate becomes hotter/colder and more importantly less humid.

Understandably people respond to high walls of green plants, but futuristic, rendered drawings of cities with high-rise buildings covered in a verdant cover of plants are an unreality in many cities as the upper levels are more likely to succeed when covered with smaller silver leafed plants. At a certain point, the energy and water needed to sustain luxurious green plantings undermines the ESD return. Growing people's awareness and acceptance to silver wall gardens where plants like Tillandsias are used will facilitate more efficient plant systems on a wider range of structures.

CAGE - EUREKA TOWER - EXPERIMENT 2014

Although only four meters from the ground, *Airborne* was juxtaposed against the second tallest building in Australia which called out for our next experiment. After contact and one meeting with the Fender Katsalidis designed Eureka Tower management, we had consent to proceed with a Tillandsia experiment. On 17 June 2014 Grant, Stu and myself installed some Tillandsia plants in wire cages attached to fixing points at four locations on Melbourne's tallest building Eureka Tower. A simple experiment - plant cages with two species in each cage were installed at level 56, 65, 91 and 92.

As far as we know this is the tallest plant install on a building in the world. Marina Bay Sands Singapore, is at 55 stories, so it is a significant step upwards and opens a new but effective way of incorporating plants on high rise buildings.

On 16 Oct 2014 we checked the plant experiments on Eureka Tower. It was wild weather with fine saturating rain driving in on a strong wind and not the most pleasant place to be at that height. The plants had survived the past four months of winters cool, wild salt winds and apart from some old leaf die back (these are the leaves farthest from the growing tip) which is probably attributed to the acclimatization to the plants to the new environment, they are fine. The Tillandsia at all four locations are growing well. Everything is secure, nothing has blown away and one plant at level 91 is even flowering. The next phase is to see how the selected species of Tillandsia perform in the dryer and hotter months ahead. On 25 February 2015, Stuart and myself visited the plants on all four locations with Angela Fedele, a writer for Sourceable, from which she published a piece in titled "Air Plant Experiment Happening Atop Melbourne's Eureka Tower."[3]

The air plants have lasted well through a very demanding, dry summer. The eight plants on all four sites are all alive and interestingly the plants exposed to strong coast winds at the very top of the structure at level 92 are performing well. The plants on level 56 facing west also receiving the extreme weather are also growing well and have put on the most growth. One of the plants in the most sheltered position at level 91 has the least growth. This site receives the least rain and sunlight. However this is also the only plant to have flowered during the experiment period but the plant does have new pups forming. The other plant on this site at level 56 is growing fine.

The experiment successfully proves that the Tillandsia plants can be grown with no soil or auxiliary watering system on the tallest of buildings and opens a portal for installing plants in a creative but effective manner with an extremely high ESD (Environmental Sustainable Design) rating on super high-rise buildings. The management of the Tower have been very supportive of the experiment, accommodating to work with, and there is potential for a larger project in the future.

FIGURE 27: The tower is named after the Eureka Stockade, a rebellion during the Victorian gold rush in 1854. This has been incorporated into the design, with the building's gold crown representing the gold rush and a red stripe representing the blood spilt during the revolt. The blue glass cladding that covers most of the building represents the blue background of the stockade's flag and the white lines also represent the eureka stockade flag.[4]

While the plant cages are designed to protect the Tillandsia plants from being blown away, they are also a reference the only person imprisoned as a result of the Eureka Stockade, Henry Seekamp Editor of the Ballarat Times, who was found guilty of seditious libel.

FIGURE 28: Grant Harris works in the background while the Tillandsia plant cage in the foreground is ready to be installed.

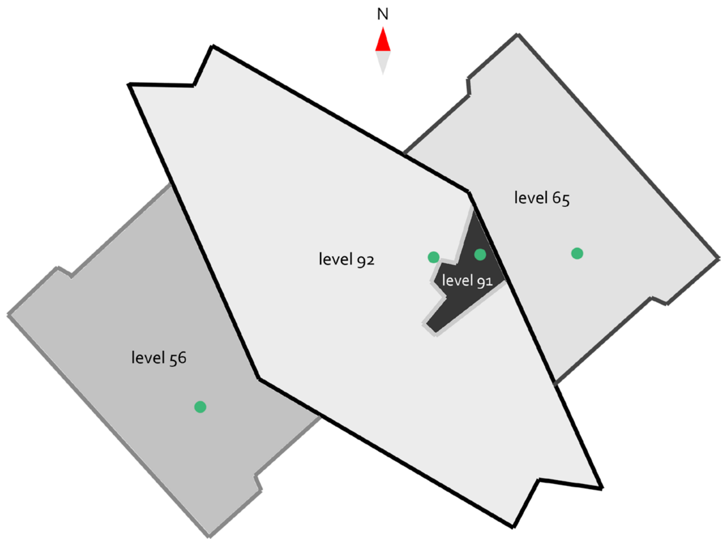
FIGURE 29: Tillandsia on Eureka Tower level 92 -fully exposed to the winds and weather - 16 Oct 2014.

FIGURE 30: Grant Harris environmental scientist, Lloyd Godman ecological artist and Stu Jones structural engineer, on Eureka Tower level 92 about 300m at the top - 200km plus winds. Now we wait to see how they grow! (the air plant cage is above Stu's head).

FIGURE 31: Tillandsia experimental test Cage anchored to a drain outlet.

FIGURE 32: Stuart Jones & Lloyd Godman check the plants on Eureka Tower level 92 on 25 February 2015.

FIGURE 33: Locations of Tillandsia plants on Eureka Tower.



SPICEE - 2015

From 22 - 29 March 2015 I was invited to be Quaker in Residence at the Art department in Friends School Hobart. As part of this residency I spoke to many groups of students about how Quakerism informs my ecological art.

As part of the residency I also worked with students to create a living Tillandsia air plant sculpture that was installed, and will remain, at the school continuing to grow. This is the first permanent installation of these living art works. When the plants have grown in a few years time, we are planning to harvest the excess growth to create more living air plant art works with another group of young enthusiastic creative art students. As an ecological artist in an age of pressing environmental concerns, the greatest legacy I can leave to future generations is an art work that cleans the environment, feeds the spirit and grows to offer the next generation of young artists a living medium to harvest and then create their own living plant sculptures.

The work utilizes tubes and cables to retain its physical integrity in a tensegrity form. The wires that hold the structure in place then have the air plants attached. The final work is constructed from stainless steel and uses six tubes, one for each of the acronym SPICEE - this represents the Quaker testimonies and bear witness to Simplicity, Peace, Integrity, Community, Equality, Earth Care. A testimony is neither a rule nor a creed, but is both an ideal to strive for and a way for our lives to speak. No testimony stands alone. They are like threads which we weave in and out of each other to create the material of our lives. I spoke to the students about the metaphor of this in the tensegrity model. When these testimonies are strong in our lives and an event or situation places pressure on the ideals of one testimony, the tensional integrity of the others pushes back to resolves the equilibrium of the one in stress.

HARD AND SOFT TISSUE PLANTS

Plants that we might incorporate into the fabric of a high-rise building can be divided into two types, hard and soft tissue. Of course there are countless variations in between, but for convenience we will outline the difference between the two extremes.

FIGURE 34: A rendering of the work on site at Friends School of the tensegrity icosahedron air plant Sculpture.

FIGURE 35: Technician, Nic Maxwell installing SPICEE - the first permanent suspended rotating air plant sculpture, Friends School, Hobart, Australia - March 2015.

Hard tissue plant material are trees that have solid trunks and branches. Examples of these within the high-rise built environment are the impressive row of tall palm trees on the roof of the Marina Bay Sands in Singapore at level 55 – 200 m up, Milan's recently completed twin apartment towers Bosco Verticale with 900 trees placed at sites on the facade and roof up to 110 meters high, and the planned 46 story Clearpoint Residencies in Sri Lanka which is due to be completed in 2015. While it is encouraging to see these initiatives to bring nature and trees back in to the urban environment, there can be risks.

The roots and main trunk can be successfully anchored down to the structure of the building, but securing all branches that could break off is impossible. In nature branches do break off, but in general circumstances the trees are rooted to the ground and the branch falls a relatively short distance to earth. Even in this situation falling branches do damage, inflict injures and kill people.

When large trees are mounted on high-rise buildings and a branch breaks, either from its own weakness or a violent storm, the material has a greater distance to fall to the ground. If this is several stories - say 30 or 40 stories - the gravitation pull means the branch will reach terminal velocity. The exact speed is determined by the fall distance, weight and aerodynamics or gravitational resistance of the material. Heavier wood with a greater moisture content and fewer leaves will reach a greater speed than lighter wood with more leaf material. The important point is that this loose material will hit the ground with greater impact than a tree growing at ground level. Further to this is a factor called wind throw. Here the material can be carried along with the wind and impact many metres from the source.

With the changing climate predictions suggest more extreme weather events and intense storms, so the risks of hard tissue plants breaking, falling or being thrown from the anchor point increases. Any branch torn form a tree located in the centre of a large roof garden may be blown across the roof and off the edge. While the actual trajectory of a falling limb in a storm may be erratic, a simple equation based on a constant decent shows that twice the height equals twice the distance from the source. From a height of 30 stories the branch may be carried 100 meters, whereas from a height of 60 stories the branch would be carried 200 meters.

The branches of substantial hard tissue plants at elevations should be regularly checked by a qualified arborist for defects and weakness. Appropriate and selective pruning will reduce resistance to wind gusts.

By contrast soft tissue plants have no dense, hard tissue, have a greater percentage of leaf material, and weigh far less, so if they fall from a similar height the terminal velocity is greatly reduced. In fact some material, like individual leaves, may actually be uplifted on air currents and even land at a higher elevation. Plants like the Tillandsias we have been experimenting with are soft tissue plants, they have little weight, with a leaf stru¬cture which assists airborne flotation, so that if they detached and fell a great height to hit a person, the impact would surprise but not result in injury. Many vertical and roof gardens utilize soft tissue plants which if detached would cause minimal to no damage. However it is possible for clumps of soft tissue plants to detach and fall to ground with a consequently greater impact. The medium plants grown on a vertical wall garden can be substantial. For instance, the 21 meter high living wall at Victoria Station, London contains 10,000 plants and has 16 tons of soil which becomes even heavier when loaded with water.[5] With any vertical garden, there is also the risk that an area of the medium could detach and fall.

MAINTENANCE OF CURRENT VERTICAL GARDEN SYSTEMS TO AIR PLANTS

Whenever any plant grows, at some point the tissue has to die. Often plants that grow quickly and produce luxurious leaves also have these leaves die quicker. While they can look fantastic, they can be more effected by extreme climatic stress - heat, wind, lack of water. In recent years it seems there has been a race to claim the largest or highest vertical garden. But as plants are installed higher up buildings, as in the One Park Building up to level 33 in Sydney, Australia, the climate alters. Constant wind becomes a factor that pulls moisture from the plant when the stomata is open during the process of photosynthesis. The One Park complex has a team of five to six gardeners constantly maintaining and replacing plants.

Successful application of integrating the living texture of plants into the fabric of a building is dependant of four factors: Species - Aspect - Acclimatization - Extremes. Selecting the right species for the aspect and acclimatizing the species before installation is crucial, as is understanding and managing extreme events. I witnessed an example of poor species to aspect adaption in a vertical wall garden in Melbourne Central Station. The garden design had a section of Vrieseas planted on a reticulated wall. As specimen plants coming into flower, the inflorescence which can last for months, they looked stunning. However, Vrieseas are another genus of Bromeliads and as mentioned their water uptake is through the leaf, so the constant water at the root causes rot, while lack of moisture on the leaf caused dehydration. Not surprisingly the plants slowly lost their vibrancy and vigour before they died. But more surprisingly the Vrieseas were replanted several times with the same affect before the wall garden was eventually decommissioned.

With a reticulated watering system, an extreme event might be:

- a pump failure or blocked pipe or drain
- extreme weather event like wind, cold, heat, dryness
- tracking, where the liquid tracks from the wall down a leaf surface and falls onto the ground below which denies the plants below this point water

Vertical and roof gardens most often fail because these factors are not considered. Because Tillandsias have no need of soil medium or a reticulated watering system the risk factors are reduced. Importantly, there is also no risk of water entering an undesired aspect of a building, as there is no risk of roots penetrating and damaging the façade or structure.

SUPER SUSTAINABILITY

As Bromeliads grow asexually, the living art works are super-sustainable, that is over time they can be harvested to provide a bio-resource to create new works, as in the work at Friends School. A significant advantage of integrating Tillandsias into a green building design is that a living wall can be completed in sections, where over time the plants are harvested and assigned to the next section of a wall. A high-rise façade might be completed several levels at a time. Unlike current vertical gardens, there is no operating cost of water, pumps, no new replacement plants. In fact, managed accordingly, living walls and suspended sculptures using Tillandias can actually generate an income for the building owner.

ADAPTION OF GREEN PUBLIC ART - THE FACADES OF BUILDING AS CREATIVE NEW SPACES

Unlike other art forms which often create more dead pixels in order to present their sustainable themed art, this super-sustainability is one of the truly unique characteristics of creating art with plants, and is especially so with Tillandsias

Through the direct use of appropriate plants in their work, artists have the potential to occupy the largest of gallery walls and spaces in both a permanent and super-sustainable way, reach the widest possible audience and effect real change in the urban habitat. The walls, roofs and "alpha spaces" of our cites are the blank canvas of the 21st century, these are the spaces artists must invade with their ideas and living green medium. Plants are a new (old) medium and one we must begin to use more often. By assisting plants to colonize the bare surfaces that are our buildings and the sky space between them in an imaginative manner, contemporary artists can evolve a blue print of urban nature and green spaces as fundamental as the discovery of single point perspective. If we turn to art action, future generations will experience this next millennium in a sustainably positive manner.

PLANTS AS LIVING TEXTURE

Buildings can be a statement within the city. Glass, concrete and metals like coloured steel, stainless, zinc, copper each have their own aesthetic quality and contemporary architects use these to design stunning structures that most often relate the materials to a defined geometry within the overall structure. However, responsible architecture of the 21st century not only has the potential to consider the advantages of plants within the urban environment and simply tack on a vertical wall garden, but draw from the diverse array of possible living textures of green to silver grey, juxtaposing them against existing materials and textures into the overall visual design of the structure at the concept stage.

PLANTS AS WEATHER SHIELDS AND SCREENS

As the silver Trichome cell which adorns much of the leaf surface of Tillandsias reflects up to 93% of the light that falls on them, these plants are excellent for living heat mitigation screens.

Because of their very light weight and adaptive biology, Tillandsias are ideal plants to use for weather shields and sun screens, even on the highest facades. Whereas vertical gardens weigh up to 70kg/sqm a screen mounted with Tillandsias weighs arout 3kg/sqm. While the weight per sqm depends upon the density of the plants on the screen, the extraordinarily light weight of these living structures affords applications that are unimaginable to reticulated systems that cannot overhang a vertical axis.

Unlike vertical gardens that demand reticulated water and nutrient systems and most often sit directly against a building's facade, with air plant systems there is little infrastructure required, Tillandsia screens can be set off the building by up to a meter or even more. We have experimented with Tillandsia screens which can be moved across windows for heat mitigation. From inside the building looking outside these screens have a lace like effect allowing dappled diffused light to enter the building. Rather than attaching the plants to a fixed screen, they can be designed in various configurations. They could be:

- moved horizontally or vertically in parallel from the building's facade across a window
- they might rotate on a curved axis so while they can be set to block direct sunlight they also allow a clear view out the window
- they might be set on a swivel off the building and rotate
- sit horizontally out from the building for shade and hinge upward

On Lloyd's St Andrews house, two double glazed skylights sit on a steep inclined roof letting welcome light into the room during winter and cooler days. However, on days 35ºC to 40 ºC plus, despite the double glazing, excessive heat enters the room. For next summer we are designing movable plant screens that act as living blinds to cover the skylights on intense days when direct sunlight enters the room and can simply be moved on pulleys up or down as the conditions dictate.

FIGURE 36: Experimental movable living Tillandsia plant screens for a building. The South China Morning Post[6] base in Hong Kong published an article on the plant works in Melbourne. The editor also wanted a shot of the experimental movable air plant screens I have at home. As I did not really have a good photo and the setting was not sympathetic, I took the curtain at the house added some more plants and set it up on a neighbour's house a few km away.

FIGURE 37 The house already had a screen system so it gives a great comparison to the plant screens. So after an hour or so it looked like this - the screens can be moved from the widow to the façade of the building. This is a prototype and they need more development but it gives a good idea of the concept. Of course the screens could easily be applied to a multilevel building.

FIGURE 38: View from inside of experimental movable living Tillandsia plant screens.

FIGURE 39: Tillandsias in a plant screen in flower in April. While the flowers are small, the bright inflorescence and bracts can last for 3 to 4 weeks. Using several species can afford another flowering in November.

BEYOND VERTICAL - INSTALLING PLANTS ON SURFACES THAT DEFY GRAVITY

Because there is no need for reticulated liquid these screens can defy gravity in ways that are restrictive for other vertical gardens systems. They can be mounted on façades that overhang or have complex intricate geometric or organically curved surfaces. For future green architecture they offer a flexible living texture with little maintenance that can be juxtaposed against glass, steel, concrete. In fact it is possible to create living facades that alter their shape and form during the day.

In 2012 Matt Blackwood and I submitted a proposal for a major commission for the new City of Melbourne Library building that was positioned on the wharf above the tidal water at Docklands. The proposal included tidal Tillandsia gardens, where screens mounted on the building would move at different rates up and down the facade of the building driven from tidal action. We would take 1 meter of tide and turn this to 5 meters of vertical movement. The concept would be ideal for coastal cities like Hong Kong and was picked up in an article on our work by the South China Morning Post.[7]

THE CONCEPT OF ALPHA SPACE

With the suspended air plant work, we are interested in exploring how plants can occupy space but not necessarily surface. Suspension on and via wires extends the potential habitat of plants within the urban environment in what we term Alpha Space. While vertical and roof top gardens have become popular in major cities worldwide, they occupy surface, a roof or wall, but the Airborne project for City of Melbourne Arts 2013, proved the intriguing and ground breaking concept that air gardens can successfully step beyond earthly confines to even rotate suspended in air or Alpha space. Utilizing a modular system, they might be suspended across an open public space like a plaza during summer where shade is welcome, and then simply moved onto a building's façade for the cooler winter months. These suspended three dimensional rotating air plant sculptures we have been creating also throw intriguing animated shadows on the ground and or walls which reflect the changing position of the sun.

FIGURE 40: *Pulse* - 2014 - rotating air plant sculpture in Alpha Space.

FIGURE 41: *Pulse* - 2014 - rotating air plant sculpture in Alpha Space.

On roof gardens suspended Tillandsia screens can be designed to create dappled shade patterns to compliment other less stress tolerant plants that might grow on the roof surface below. Unlike current vertical wall or roof top garden applications, the approach is not to adapt the built environment to suit the desired plants but use plants that have evolved a specific biology to withstand the rigours of the urban environments we have created - pioneer plants like Tillandsia.

Air gardens in alpha space break new ground, offering fresh dimensions by incorporating plants in our cities via innovation with an extremely high ESD. They write a fight manual for plants to escape their earthly confines in the urban habitat and occupy new space within our cities.

FIGURE 42: *Pulse* - 2014 - Alpha Space Time exposure of Pulse - commission for the Green Cites Conference in the Ball Room of the Grand Hyatt, Melbourne 2014.

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