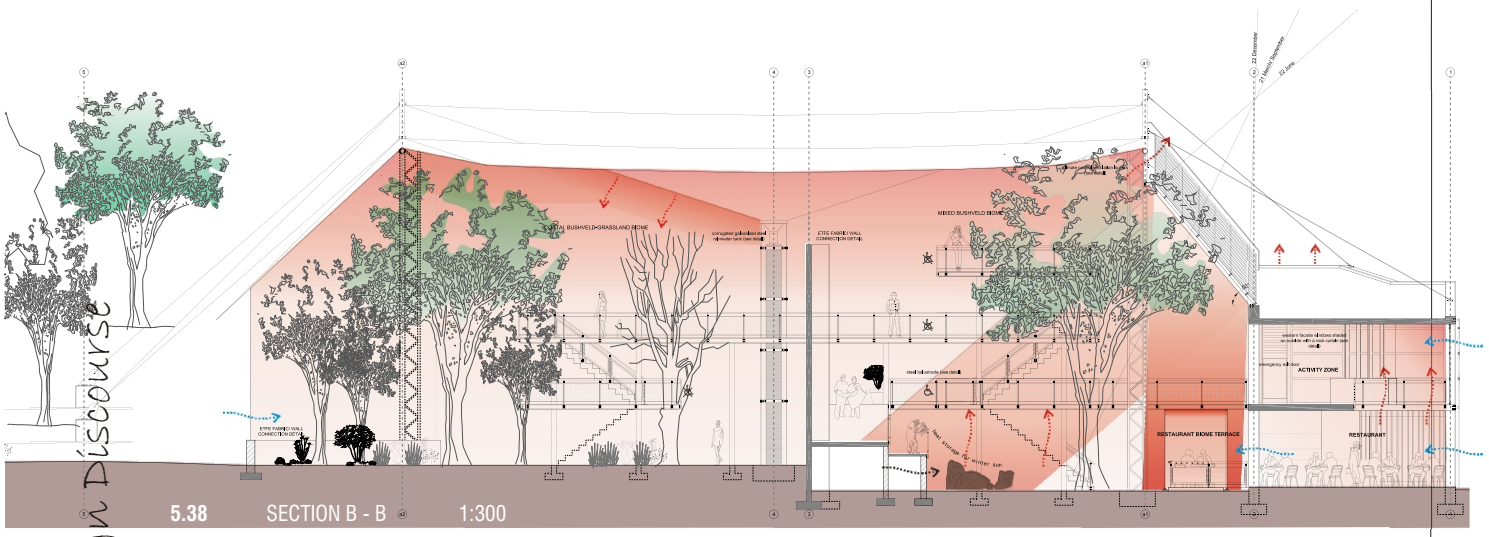
The following section covers aspects of the biomes that are important to the design and functioning of systems.

The climatic zones within the conservancy represent three of the seven biomes in South Africa. Three areas are represented due to the vast, but overlapping distribution of butterfly species within South Africa. There are three prominent distribution areas Savanna, Fynbos and Mixed Bushveld.
Refer to Appendix D for a detailed description of the biomes, climates and examples of the type of plant and butterfly species found in each zone.



5.38 SECTION B - B 1:300

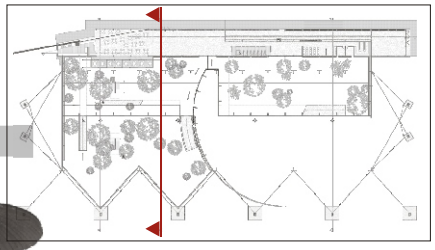
ENVIRONMENTAL STUDIES

Climatic Zones

The three climatic zones can be classified into two biomes, of which South Africa has seven. The classification is very complex due to the over lapping of plant and butterfly species within the different biomes. Table 5.39 illustrates the vast over lapping of biomes within the provincial boundaries.

	Biomes	Acocks Veld Types	Number of species				
			Plant	Mammal	Bird	Amphibian	Reptile
Eastern Cape	7	29	6164	156	384	51	57
Free State	3	17	2984	93	334	29	47
Gauteng	2	8	3303	125	326	25	53
KwaZulu-Natal	4	19	8141	177	462	68	86
Mpumalanga	3	15	4782	160	464	48	82
North-West	2	11	3025	136	384	27	59
Northern Cape	6	18	5067	139	302	29	53
Northern Province	3	14	4236	239	479	44	89
Western Cape	6	18	8925	153	305	39	52

5.39: Biodiversity values for provinces in South Africa



5.40 KEY PLAN

The climatic zones will allow plant propagation and create a habitat for butterflies. Because each climatic zone is different, each space is specially designed to accommodate passive regulation of the climate which will contribute to relevant plant growth and butterfly habitat. It is important to maintain large openings for natural day lighting as most plants rely on direct sun light to grow and survive. The most important environmental factors which affect the aerial parts of the plant include light, temperature, humidity, air changes and gases.[1]

Figure 001: Parides iphidamas by Ryan Pettey

1. von Zabeltitz, 1999

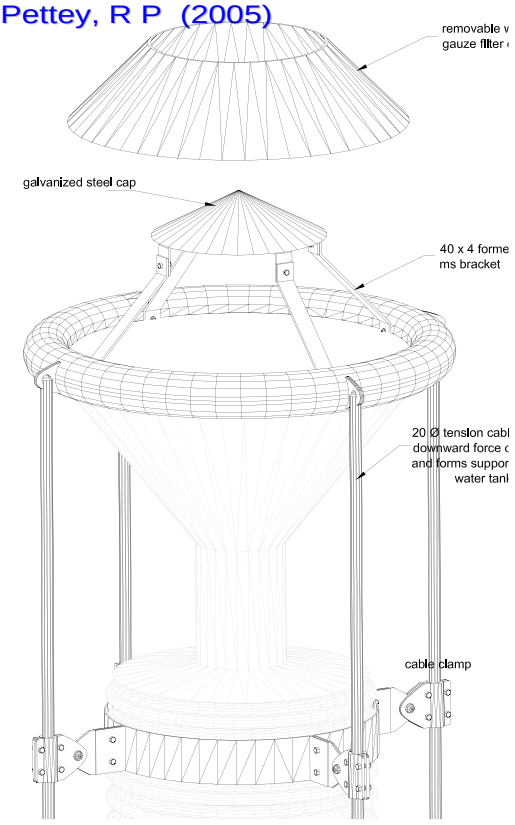
CREATING AN ENVIRONMENT

Sun Penetration and Heat Gain

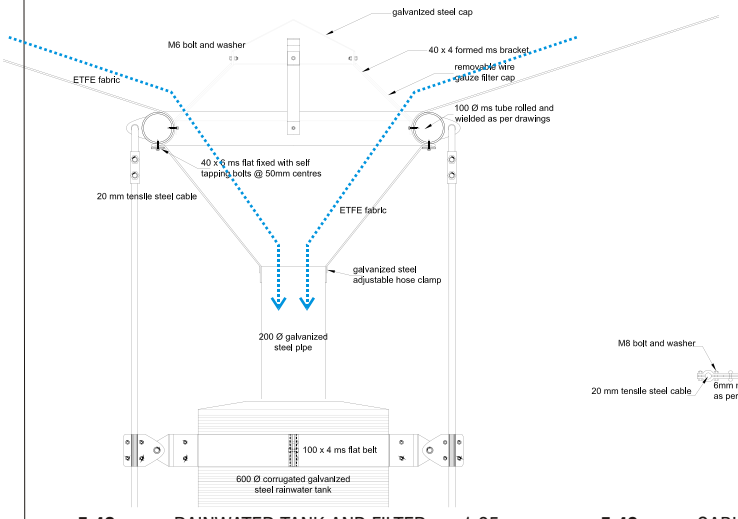
The higher the light transmission into the biomes the better the plant growth. von Zabeltitz (1999) recommends that green house glazing be at an angle of between 25° to 65° for maximum light transmittance. The northern facade of the biomes is glazed - at 50°- to allow maximum sun and heat gain. (5.38) The rest of the biomes structure will be covered with translucent fabric.

Storing the Heat which accompanies the Solar Gain

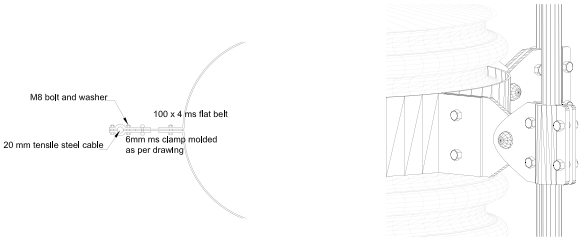
Mass heat storage is used in the form of boulders which are positioned in the zone that receives winter sun. Heat storage in the form of water pools that replace boulders are also possible if humidity isn't altered. The concrete ramps also contribute to the heat storage. Mr P Nel recommended that 20% of the floor area contribute to heat storage.



5.41 RAINWATER TANK AND FILTER 1:25



5.42 RAINWATER TANK AND FILTER 1:25



5.43 CABLE CLAMP AND STEEL BELT CONNECTION 1:25

Rainwater Collection and Storage

Water collected off the roof will be used in the biomes to water plants and to provide the water needed to increase the humidity in the Coastal Bushveld - Grassland biome. There are four rainwater tanks, each with a holding capacity of 3000 litres. The total annual water collection per tank is 44 537 400 litres (roof area per tank 654m^2). Overflow water will be diverted into the existing borehole storage system.

Figure 001: Parides iphidamas by Ryan Pettey

2. Holm, 1996:29

Humidity Control

Increasing humidity in the Coastal Bushveld - Grassland biome can be achieved by evaporation of water. A high pressure fog system, which is automated with humidity sensors is to be installed above the canopy of plants. A fine mist is released which with the high internal temperature immediately humidifies the air. The butterflies are not disturbed by this mist but actually thrive in it. In the other two biomes the same system can be used to cool, and hydrate the plants. It is important to achieve the correct combination of air exchanges and heat control to create the correct climate.[3]

Heating and Energy Conservation

It is very important to maintain a constant average temperature. A low minimum temperature will reduce the rate of growth whilst a wide diurnal range, or very cold periods, may kill plants. Optimum plant growth normally occurs when the night temperature is 5 to 8 deg C lower than the day temperature, although plants appear to develop a preference for lower night temperatures when they mature.[4]

The purpose of the cladding is to separate the inside and outside environments and to transmit as much useful light as possible. The inside environment is maintained for optimum plant propagation, while the outside environment is exposed to local weather conditions.

Reducing heat loss by making the correct choice of cladding material is important for the conservation of energy. A comparison of the different materials heat-loss coefficients (U value) is an indication of the thermal properties of that material (5.44). Most glass greenhouses are clad with a single layer of glass resulting in a relatively high heat loss coefficient. Rigid plastics (e.g., polycarbonate or acrylic) are less expensive than glass and last for 10 to 20 years. They are usually manufactured as corrugated single-layer or twin-walled sheets. Their light transmission is very good, although this usually drops over time due to the aging or yellowing of the plastics.[5]
The use of rigid plastics was an option in place of glass (which covers most of the northern facade) but due to the unfavourable properties with regard to light transmission and yellowing over time, I decided that glass would be the appropriate choice.

On greenhouses, plastic films are almost always installed in two layers that are inflated by a small fan. The air space between the two layers acts as an insulator, significantly reducing the heat loss from the greenhouse. Air inflated greenhouse surfaces experience approximately 60% of the heat loss compared to similar surfaces clad with a single layer of glass or plastic film.[6] To conserve energy the butterfly conservancy will be covered with a double inflated film .

Another mean of energy conservation is with movable thermal screens which can be closed at night . This method allows maximum light penetration during the day and minimal heat loss at night. This is an excellent means of energy conservation, but after much debate the double film was decided upon. The shape of the conservance roof as well as the fact that butterflies could be caught on the wrong side of the thermal screen made this option less favourable.

Material		Thickness	Light Transmissivity	IR transmisivity	Heat consumption coefficient
		mm	%	%	u ($Wm^{-2}K^{-1}$)
Glass	Single	3.8	89-92	0	6.0 - 8.8
	Double				4.2 - 5.2
Double Acrylic		16	86	0	4.2 - 5.0
PVC	Single film	0.1 - 0.2	87-91	17-30	6.0 - 7.8
	Double film				4.2 - 5.5
ETFE	Single film	0.1	93	22	6.0 - 7.8
	Double film				4.2 - 5.5

5.44

5.45

Figure 001: Parides iphidamas by Ryan Pettey

3. von Zabeltitz, 1999 | **4.** Scrivens, 1980:21 | **5.** von Zabeltitz, 1999:43 | **6.** American Vegetable Grower, 2004

Ventilation and Cooling

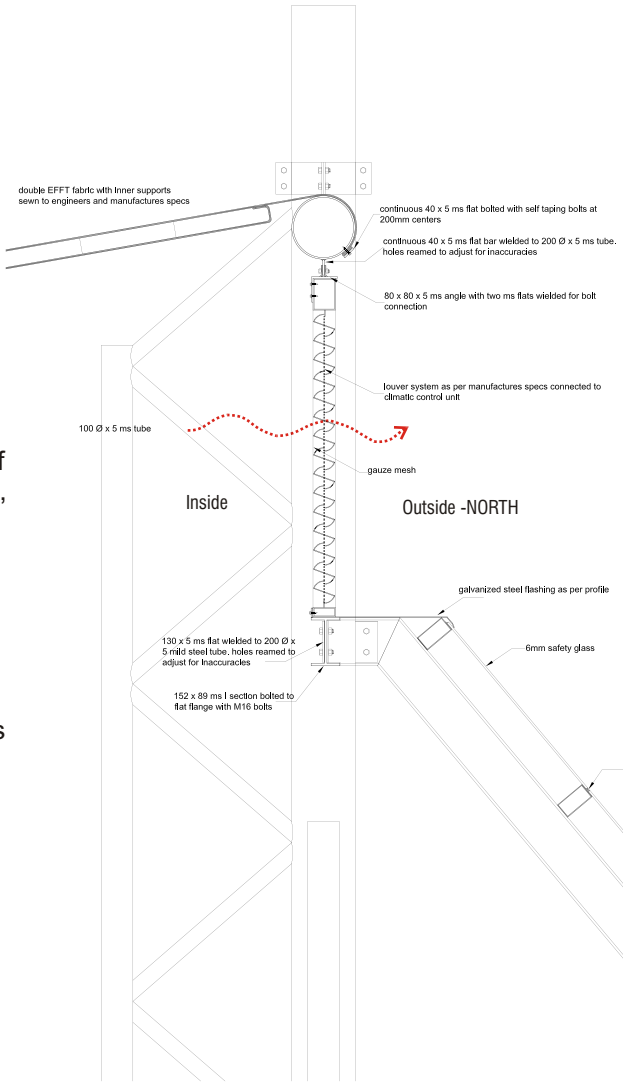
Ventilation of the biomes depends on the exchange of air between inside and outside for the purpose of:

- exchanging carbon dioxide and oxygen
- dissipation of surplus heat and temperature control
- humidity control

Sufficient ventilation is very important for optimal plant growth.[7] Two different types of ventilation systems are available - natural and forced ventilation. Natural ventilation relies on the movement of air by convection currents from a low pressure to a high pressure, whereas forced ventilation is achieved by utilizing fans which physically move the air.

The butterfly conservancy's design relies solely on natural ventilation. Louvre ventilators at the top of the tensile structure have been provided to allow - if needed - hot air to escape. For sufficient ventilation, Openings should be between 15 - 25% of the floor area, of which roof vents are the most efficient.[8] With the loss of hot air through the top a vacuum is created that is filled by air drawn in through the bottom of the structure. The louvre ventilators will be automated to open and close as the climatic control system regulates all the systems responsible for climatic conditioning. The ventilators will also be fitted with nets to keep butterflies in and birds out.

The design allows passive climatic regulation of all the climatic zones. Fine tuning of the climates will be done once the structure is built and occupied.



5.46 CLIMATE CONTROL AND VENTILATION LOUVER 1:25

Figure 001: Parides iphidamas by Ryan Pettey

7. von Zabeltitz, 1999:47 | **8.** von Zabeltitz, 1999:48

Implementation and Management

The objective of the landscape design is to allow natural communities of plant life to establish a self sustainable and self regulating ecosystem. Initially the establishment process will be labour-intensive. Correct training and education of staff will be very important.

Construction - step by step

The ridged core The first stage in the construction process will be to erect the concrete structure. These elements form the structural components onto which the fabric is fastened.

Steel structure The second stage will be the erection of the steel columns which form the compression members that support the fabric.

Sub structure and in-fill Once the fabric is positioned, accurate positioning of foundations and in-fill panels is possible. All other works can then be completed.

As with the site design, staff using the conservancy will need training and education in the use of the passive climatic system, which is integral to the correct functioning of the building.

Cleaning the structure will be minimal. Areas which will need cleaning are the glass facades and from time to time the roof fabric which will not be a problem as Mr Pretorius[9] from Bild Architects assures me that the fabric will be so taut that a person will be able to walk on it if cleaning is required.

Figure 001: Parides iphidamas by Ryan Pettey

9. Pretorius, 2004

MATERIALS

Cladding Material - Comparing Greenhouse Coverings

Plastic film

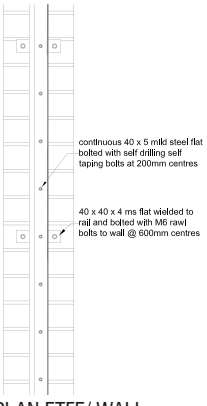
Various types of plastic film are used as cladding materials for greenhouses. A problem with many of these plastic films is their limited life span. Polyethylene film has a maximum durability of one year, even with ultraviolet stabilizers the product only has a two year life span.[9] Durability is very important in the conservancy as the material cannot be replaced every year for economic and practical reasons. The use of more durable material with a life span of between 15 and 25 years is more appropriate.

Polyvinyl chloride film - PVC

Polyvinyl chloride, commonly known as "PVC" or "vinyl," is one of the most common synthetic materials. Approximately 75% of all PVC manufactured is used in construction materials. PVC is the worst plastic from an environmental health perspective, posing major hazards in its manufacture, product life and disposal.[10] This is a good enough reason not to use the product, although of all the materials which were researched PVC was the most commonly available material in South Africa. PVC has a light transmissivity of between 87-91%.

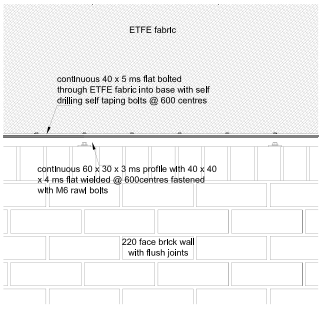
Ethylene tetrafluoroethylene - ETFE

150,000 square metres of ETFE foil will be used to cover the new German soccer stadium Allianz-Arena, where the opening match of the 2006 World Cup in Germany is to be held. When completed, the stadium will be the world's largest structure made of ETFE foils. The sports facility calls for: making the side wall and roof smooth and curved; allowing ultraviolet rays needed to grow lawn; and enabling a colourful performance using the side wall and roof - transparent or translucent - as monitor screens. To realize this specification, sheets of double-layered ETFE foil, or cushions, are fit in the cells of the side wall and roof, and then inflated by compressed air.[11]

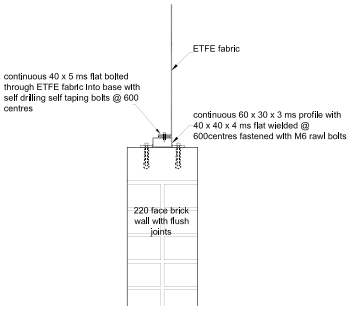


5.47 PLAN ETFE/ WALL CONNECTION 1:25

Environmentally this is the better option but I was unable to find any source of the product in South Africa. Depending on price and eventual embodied energy of the product, (due to its sourcing) ETFE is the covering that is to be used in the conservancy.



5.48 ELEVATION ETFE/ WALL CONNECTION 1:25



5.49 SECTION ETFE/ WALL CONNECTION 1:25

Refer to Appendix E for an example of FTFE.

5.50 PUPA: LEAVES

5.51 PUPA: SILK

5.52 PUPA: THORNS

Figure 001: Parides iphidamas by Ryan Pettey

10. von Zabeltitz, 1999:43-44 | **11.** Institute of Local Self-Reliance, 2003 | **12.** Asahi Glass Co, Ltd.

Figure 001: Parides iphidamas by Ryan Pettey

MATERIAL CHOICE

- Architects are faced with decisions as to a choice of the materials they use which in turn are determined by environmental constraints. Buildings have to provide a separation between inside and outside to maintain levels of comfort and they must be structurally sound to support their own basic self-weight and applied loading.

5.53 - 5.59

VEGETATION

Vegetation is not normally seen as a building material but could possibly be one of the most important elements in a environmentally sensitive scheme. Growth structures are in essence deciduous plants grown over structures which in turn shade an element, area or system from solar penetration. A growth structure is similar to a shading device only being different in that when solar penetration is required in winter the growth structure dies back (deciduous).

PLASTIC FILM

"The material of our age, yet still not really present in the expression of space and the construction of buildings, except in services such as electrical and plumbing. Plastic can easily be used to define space, to shelter and to reveal only a hint at what is hidden behind it" (Boer, P. 2000).

The three biomes will be covered with a tensile film of Ethylene tetrafluoroethylene - ETFE. This application will need to be designed and constructed by a specialist. The tensile structure will be the first phase of construction, thus an area which is secluded from environmental impacts ensuring contractors are able to continue work come rain hail or snow.

CONCRETE

Initially the conservancies design incorporated precast floor slabs, but a conscious decision rather to use cast in-situ concrete was later adopted. As precast concrete is manufactured in a factory all monetary value is directed to one enterprise. On the other hand cast in-situ concrete can incorporate local labour thus uplifting local communities. The final product regardless of the method used, will remain the same.

Cast in-situ mass concrete walling is also used for the east and west facades. Concrete can also have enough mass to be an effective thermal storage device.

WOOD

As a materials with one of the lowest embodied energies, wood should become a more used commodity in the South African building industry. Wood can be used to replace certain components which are high in embodied energy and aren't necessarily fundamental to the design or functioning of the building.

The louver windows in the butterfly conservancy are fitted with wood, as ample light enters through the rest of the window. The louvers then act as ventilation and shading elements which promotes passive climatic regulation and reduce embodied energy.

BRICKWORK

Much of the attraction of brickwork lies in the textures, colour and variations that arise from the use of materials, made from various clays and manufacturing processes. In addition to an attractive and durable appearance , brickwork can give weather resistance, support loads, provide thermal, sound and fire resistance.
Most of the internal walls are brick which satisfy the design and technical requirements and also promotes the requirement of local unskilled labour.

STONEWORK

Climatically responsive structures in hot dry climates rely, amongst other things, on mass. In the past houses were built of thick rock walls and had recessed windows. This type of construction had a positive climatic response, reducing the need for extra internal heating or cooling.
Trombe walls work on a similar principle of providing mass storage for thermal energy. Throughout the conservancy there has been an attempt to integrate rock trombe walls as well as in-fill panels of rock to contribute to the thermal mass of the structure.

STEEL

All the steel components are modular and can be prefabricated by local craftpersons.
As a rule, wherever possible elements have been designed to the simplest specification possible. This will allow emerging contractors and local craftpersons to be involved in the manufacturing of components.

Figure 001: Papilio iphidamas by Ryan Pettey

A Final Word

Naturally lit areas, the lightness of the structure and the large open spaces are evocative of your host - The Butterfly, - you are in Butterfly Territory.

The flutter of fabric in the wind alludes to the presence of environmental elements. Naturally ventilated spaces planted with trees and shrubs from around South Africa are a flutter with a variety of butterfly species. The rich, sweat smell of soil and the fresh, clean smell of vegetation will permeate the senses, as the visitor pauses to admire the beauty of these amazing insects, while all around, the natural life cycles continue uninterrupted by the presence of man.

Figure 001: Parides iphidamas by Ryan Pettey