THE POTENTIAL OF LIVING WILLOW STRUCTURES IN THE LANDSCAPE

by

Bonnie Gale

A manuscript thesis submitted in partial fulfilment of the requirements for the Master of Science Degree in Landscape Architecture State University of New York College of Environmental Science and Forestry Syracuse, New York December, 2011

D. Dayton Reuter, Major Professor Department of Landscape Architecture

Elizabeth Folta, Assistant Professor Department of Environmental and Forest Biology

Richard Hawks, Professor and Chair Department of Landscape Architecture

S. Scott Shannon, Dean SUNY ESF Graduate School
# Contents

List of Figures ................................................................................................................................. iii

Abstract ........................................................................................................................................ iv

Introduction ...................................................................................................................................... 1

Living Willow Structures in the United States .................................................................................. 2

Future Trends in Landscape Architecture .......................................................................................... 7
  Urbanization ................................................................................................................................. 7
  Climate Change ............................................................................................................................. 8
  Relation with Nature and Human Health ......................................................................................... 8
  Energy Issues ............................................................................................................................... 9
  Ecosystem Services, Biophilia and Living Architecture ................................................................... 9
  Green Building ............................................................................................................................. 10
  Natural Architecture and Art in the Landscape ............................................................................. 11
  Garden Design ............................................................................................................................ 12
  Ecological Urbanism, Landscape Urbanism and Sustainable Urbanism ........................................ 13

Living Willow Structures in the Past and Present ............................................................................... 14
  Fedge Method ............................................................................................................................. 14
  Poling Method .............................................................................................................................. 19
  Arborsculpture ............................................................................................................................ 22
  Grafting/Inosculation/Inclusions .................................................................................................. 25

Living (Willow and Other) Structures for a Future Changing World ...................................................... 27
  Visionaries: Arthur Wiechula, Germany ......................................................................................... 27
  Visionaries: Konstantin Kirsch, Germany ....................................................................................... 31
  Visionaries: Luc Schuiten, Belgium ................................................................................................ 31
  Visionaries: Mitchell Joachim, USA: Fab Tree Hab ..................................................................... 32
  Visionaries: Mitchell Joachim, USA: Willow Balls ...................................................................... 34
  Future Forms ............................................................................................................................... 35
  Future Forms: The Patient Gardener, Italy .................................................................................... 35
  Future Forms: Living Root Bridges, India ..................................................................................... 36
  Future Forms: Baubotanik, Germany ............................................................................................. 37
  Future Forms and Locations of Living Structures in Landscape Architecture ............................... 39

Conclusions ........................................................................................................................................ 41

References ......................................................................................................................................... 43

Biographical Sketch .......................................................................................................................... 46
### List of Figures

**Figure 1**: The Willow Dome (Calkins, 2000) ................................................................. 3
**Figure 2**: Trampoline and Willow Garden (Hamnett, 2001a) .......................................... 3
**Figure 3**: Living Tunnel in San Francisco .................................................................. 5
**Figure 4**: 8’ dome at the Children’s Learning Center, Onondaga Community College, Syracuse, NY ............................................................... 5
**Figure 5**: Living Memorial Structure, Chenango Bridge, NY ............................................ 5
**Figure 6**: Garden Pavilion, Amagansett, NY ................................................................. 6
**Figure 7**: Living Tree 1 created for CNY Blooms Flower Show ...................................... 7
**Figure 8**: Tree 2: Spring Unfurling, paint on dried willow, CNY Blooms Show ............. 8
**Figure 9**: Willow Tree Sculpture designed by Ian Hunter, Rosendale Groundwork Trust, UK, 1987 ................................................................. 15
**Figure 10**: Uprights 8 inches apart and one foot deep .................................................. 15
**Figure 11**: Horizontal binder and diagonals inserted in two sets ................................... 15
**Figure 12**: Diagonals cross on an upright and are tied ................................................ 15
**Figure 13**: Living willow chair ...................................................................................... 16
**Figure 14**: Living fitchet fence, Denmark ...................................................................... 16
**Figure 15**: Living diagonal fence, Denmark .................................................................. 16
**Figure 16**: Diagram of LEAF design ............................................................................. 17
**Figure 17**: View of Erie installation ............................................................................. 17
**Figure 18**: Detail of central monument ......................................................................... 17
**Figure 19 and 20**: Fifty feet of living tunnel as just constructed in Baltimore, September 2011 ........................................................................................................ 18
**Figure 21**: Seventeen days later! Look at the growth ................................................... 18
**Figure 22**: Detail of top and side weaving ...................................................................... 18
**Figure 23**: Poling Outdoor Living Room, Bridgehampton, NY ..................................... 19
**Figure 24 and 25**: Two views of Outdoor Pavilion, Southampton, NY ......................... 20
**Figure 26**: Auerworld Palast, Auerstedt diagrams of growth ........................................ 21
**Figure 27**: Sumerian reed knot tying technique ............................................................ 21
**Figure 28**: Plan and section of Auerworld Palast .......................................................... 21
**Figure 29**: Auerworld Palast view ................................................................................ 21
**Figure 30**: Chair by John Krubsack ............................................................................. 22
**Figure 31**: Basket Tree by Axel Erlandson .................................................................... 23
**Figure 32**: Four Legged Giant by Erlandson .................................................................. 23
**Figure 33**: Arbosculture by Richard Reames .............................................................. 24
**Figure 34**: Ficus House, Okinawa, Japan ...................................................................... 24
**Figure 35**: Types of Approach Grafts ........................................................................... 25
**Figure 36**: Natural grafts of joints tied with elastic, LEAF installation, Erie, PA ............ 26
**Figure 37**: Bicycle in the Tree Inclusion, Vashon Island, Washington ......................... 26
**Figure 38**: Assorted drawings by Arthur Wiechula of his proposed living structures ...... 28
**Figure 39**: Living Wall Patent by Arthur Wiechula (with translation into English) ....... 29
**Figure 40**: Living Fence Patent by Arthur Wiechula (with translation into English) ...... 30
**Figure 41**: Ash Dome Plan and image by Konstantin Kirsch ......................................... 31
**Figure 42**: Work of Luc Schuiten ................................................................................ 32
**Figure 43**: Fab Tree Hab concept and stages of growth ............................................... 32
**Figure 44**: Fab Tree Hab with CNC scaffolding ............................................................ 33
**Figure 45**: Fab Tree Hab cross section ......................................................................... 33
**Figure 46**: Template for willow ball wall ...................................................................... 34
**Figure 47**: Willow ball ecotourism concept .................................................................. 34
**Figure 48**: The Patient Gardner concept visualization ................................................... 35
**Figure 49**: Sketch of proposed arbosculture methods .................................................... 35
**Figure 50**: Unveiling of The Patient Gardener, Italy ...................................................... 36
**Figure 51**: Root bridges in India .................................................................................. 36
**Figure 52**: Baubotanik Living Tree Tower, Germany, showing concept and built project . 37
**Figure 53**: Structure of the Living Tree Tower .............................................................. 37
**Figure 54**: Baubotanik Forest rest Stetten bridge, beach pavilion and Hartenholm lit tower 37
**Figure 55**: Plane-Tree-Cube in Nagold, Germany ........................................................... 38
Abstract


Living willow structures are presently used in the landscape for recreation, play, contemplation, art and shelter. Many artists, inventors and visionaries believe that permanent buildings made of living trees are also possible. This paper discusses the major trends and forces in the world that bring to bear the need for a reconnection with nature and the role that living green structures can play. There is an exploration of the major actors in the recent history, methods of construction and the visionaries who have added to the dialog. The potent present work being done in the field is discussed, followed by concluding remarks as to the potential forms and locations of these living structures in the landscape.

Key words:
Living structures, living willow structures, willow, landscape architecture, fedge, poling, arborsculpture, grafting, Arthur Wiechula, Mitchell Joachim, Konstantin Kirsch, Richard Reames, Baubotanik

Bonnie Gale
Candidate for the degree of Master of Science in Landscape Architecture, December 2011,
D. Dayton Reuter, Professor
Department of Landscape Architecture
State University of New York
College of Environmental Science and Forestry
Syracuse, New York 13210
Introduction

Willow (genus Salix) has a very broad range and history. It was one of the first flowering pre-Ice Age plants (Newsholme, 1992). Over history, it has been used (Stott, 1992) for weaving baskets and furniture, the making of cricket bats and false legs and the source of natural aspirin. More recently, willow is used in land reclamation through living woven mats, stream bank restoration, biomass production, phytoremediation, biofuels, and living sound barriers (Labrecque et al, 2005). In horticulture, art and architecture, it is also woven into living structures.

Living willow structures have great potential in the landscape for recreation, play, contemplation, art and shelter. As will be shown, many inventors and visionaries believe that permanent buildings using living material are also possible. Living structures are taken to mean tangible objects created by man using living material. Living willow refers to willow rods or stems that are alive. Willow has the ability to self-root and hence allows for the direct placement of the live dormant rods into the ground. Structural support or weaving techniques are then applied to form the definition and/or enclosure of space. The focus here is on the use of willow but the tree manipulation method does involve other species of woody vegetation. The shrub form of willow used in living structures is usually rods that have been grown in fields in closely spaced lines and forced to grow long and tall (up to twelve feet), usually over one growing season. In some applications, the willow or other woody material may be older rods or young saplings. Living willow structures are containments and definitions of space using live willow rods.

The context for this discussion is the landscape. Landscape comprises the visible features of an area of land. This definition includes both the physical natural elements of landforms, water bodies and vegetation as well as the cultural human elements of different forms of interventions, namely, land use, building and structures. Living structures have been applied in many types of land and landforms and in a variety of cultural settings.

Structures are created by three main techniques of living fence (fedge), poling and tree manipulation or arborsculpture. The fence or fedge method has allowed the creation of living fences, arches, domes, tunnels, all combinations of the above as well as outdoor living rooms. The fedge method uses the ability of willow to be woven. Rods which are extended with poles are also used to build outdoor classrooms, cathedral type spaces and art. Tree manipulation or arborsculpture involves the creation of living buildings, art and the creation of functional furniture with many tree species other than willow. In the fedge and arborsculpture methods, the ability of willow and other woods to be grafted together is a very important characteristic.

For most of the twentieth century, examples of living structures are found in Europe with the early work of Arthur Wiechula and later by Marcel Kalberer and Konstantin Kirsch in Germany. More built work and media coverage exists for living structures in Europe than the United States. A possible explanation may be that although the United States saw many experiments in pleaching, espaliers and tree manipulation in the grand estate gardens of the Gilded Age, this period was short-lived and followed by the Great Depression, which resulted in a mentality of austerity. This austerity resulted in a tendency toward rustic and ruggedly functional design in parks and public gardens. Post Second World War saw the rapid rise in international style design in both architecture and landscape, which emphasized a stylistic simplicity derived from machine-crafted aesthetic. The emphasis on hand-crafted arts was more common in European garden landscapes. Europeans placed early emphasis on the depth and quality of garden design and hence greater experimentation occurred in tree manipulation. The result is that living structures are a more recent phenomenon in the United States, early examples of which include the work of Axel Erlandson in California. Living structures have been sparsely recognized by the published media in the USA, even though they have been built for over nearly a century in the United States. This response has been due to the lack of understanding by the public and the media of their significance and potential usefulness. Living structures have been seen as oddities. This paper will discuss how living structures can blossom in the future changing world.
Global environmental trends will likely have a pronounced effect on landscape architecture in the next several decades resulting in opportunities for living structures to play a far greater role and have greater recognition as a meaningful form in the landscape. The interest and necessity to find sustainable solutions to global urbanization, climate change, use of resources and energy consumption in the next century is likely to give rise to greater opportunities for expanded use of living structures. This discussion is firmly placed within the context of architectural and planning urbanism theory, biophilia, garden design, art and green/living architecture.

Methods of construction for living structures will be discussed relative to their uses in various forms and settings. The main focus will be on their application to landscape architecture. The main intent is to relate the potentials of these structures to the United States but in order to understand the potential applications, there will be discussions of applications in Europe. Although willow is the plant of discussion, other viable species will be mentioned especially in relation to the arborsculpture and tree manipulation.

The United States has a broad range of climates and physical settings conducive to the use of living willow structures. It is the intent of this paper to show how living structures have great potential for incorporation into this landscape. The futuristic work of Mitchell Joachim and other Americans will be applied in this context and there will be discussion of the forms and locations of living structures.

**Living Willow Structures in the United States**

The application of living willow structures in the United States appears limited based on the paucity of published literature in landscape architecture. There were some articles on tree manipulation in other publications, including Life magazine of January 1957 on the manipulated trees of Axel Erlandson (Life, 1957).

There have been four applications of living willow in the landscape architecture literature as researched through Landscape Architecture magazine: the Willow Dome at Real Goods Solar Living Center (Calkins, 2000); Trampoline and Willow Garden (Hammett, 2001a); Schoolyard children’s play structures (Danks, 2002) and a willow plant profile (Casey, 2011). Each of these applications will be discussed in turn below.

In addition, as will be discussed in the later section of Natural Architecture and Art in the Landscape of the Future Trends in Landscape Architecture chapter, Land Artist, Patrick Dougherty has had his work featured twice in Landscape Architecture magazine including on the cover of the March 2001 issue. This publicity shows the recognition by the landscape architecture community of the role and value of art in the landscape.

The first application of living willow occurred in 2000 with the article by Meg Calkins entitled “A Living Structure: The Willow Dome at the Real Goods Solar Living Center”. Chris Tebbit of Land and Place landscape architects of Booneville, California designed and constructed a willow dome at the Real Goods Solar Living Center in Hopeland, California (Figure 1). Calkins (2000, 42) states:

“Building landscape structures from live plants is a sustainable building practice that eliminates the use of processed building materials, such as lumber from over stressed forests or highly processed steel, and the energy costs associated with their transportation. Building with living structures does, however, require a knowledge of the plant’s growth characteristics, effort to train the plants, and time and patience for the structure to grow. In the end, as is evidenced by the sculptural Willow Dome, the time and effort provides a big payoff with a leafy living structure.”

This quote sums up many of the issues that will discussed later in this paper; namely the benefits of a living structure with the necessity to understand the needs of the living plant and
have time and patience. The Willow Dome is used as an outdoor classroom. The Dome is made of a Salix alba and matsudana cross. The 60 diameter dome was started by planting double cuttings that were woven together into single trunks. At a height of ten feet, the trunks were bent over and new shoots were then woven to form a dense canopy. Construction took place in one day in February 1996. The cuttings were tied to form the trunks and the designers planned on the cuttings naturally grafting. The thrice yearly maintenance involves bending, weaving, and tying the new shoots. In 2000, the landscape architects were still involved in the maintenance, which may be unusual in the profession.

The second application of living willow in a structure involved a 2000 ASLA Design Merit Award winner for the Trampoline and Willow garden design at the
The total installation size was 30 feet square. The trampolines were placed under voids in the overhead piping and the participants had the experience of jumping up through the suspended willows to the voids above. This Trampoline and Willow Garden provides an imaginative solution to the design brief, using living willow. It shows a particular application of living willow applied to garden design.

The third application of living willow structures recently has been living structures in schoolyards. In June 2002, the Landscape Architecture magazine published an article entitled Green Mansions: Living Willow Structures Enhance Children’s Play Environment written by Sharon Gamson Danks (Danks, 2002). Sharon is a schoolyard ecology researcher and design consultant in the San Francisco Bay Area. Her applications of living willow structures relate to the building of living play structures that transform schoolyards. Since that time, she has published an important volume, entitled Asphalt to Ecosystems: Design Ideas for Schoolyard Transformation (Danks, 2010). She is founding partner of Bay Tree Design Incorporated in Berkeley, California, a women owned landscape architecture and planning firm that collaborates with clients to develop lively outdoor spaces including ecological schoolyards. In her book, she encourages living structures as one of many tools in schoolyard transformation. Her examples, though, are all located in Europe from her many site visits. She states:

“Dynamic living willow constructions offer dramatic focal points for school grounds. Their flexible branches bend into eye-catching shapes that spark interest and invite them to come inside... during playtime, students use leafy semi-enclosed domes and teepees as “playhouses” for dramatic play or to talk quietly and relax. When it is time for class, these spaces become meeting places for outdoor lessons. Leafy tunnels invite active running games, hide-and-seek and other activities” (Danks, 2010, 161).

Danks (2010) goes on to mention that similar techniques are now being used by some schools in the United States and shows one image of a tunnel under construction at the San Francisco Community School (Figure 3). Sharon Danks (2002, 93) concludes that:

“Living willow structures have great potential to enhance schoolyards and playgrounds in the United States. Landscape architects, restoration ecologists and other design professionals in the United States are the ideal advocates for this exciting material and will benefit from its suitability for children’s play environments and the design freedom and creativity it allows.”

Rusty Keller, a local play space designer, has built a Willow Hut at the Syracuse University Early Education and Child Care Center which is documented in his book Natural Playscapes (Keller, 2008).

The author, Bonnie Gale, started constructing living willow structures in schoolyards in 2004. The living structures often relate to a theme, emblem or mascot of the school in question and engage the students in the design, construction and maintenance. She has designed and built with the students a total of ten structures for schools located in New York, Pennsylvania
and Connecticut. The Children’s Learning Center at Onondaga Community College includes two tunnels and a dome (Figure 4). Those thematically based structures include the eagle mascot for Gilbertsville-Mount Upton Central School, New York in 2008, Stars and Moon memorial structure at Chenango Bridge Elementary, New York in 2008 (Figure 5) and the living Mustang mascot at Morris Central School, New York in 2010.

In 2006, two articles were published in House and Garden (Christopher, 2006) magazine and Vogue Living (Bowles, 2006) magazines featuring the willow structures of Bonnie Gale. In March 2006, Tom Christopher wrote his One Gardener’s Almanac in the Garden in House and Garden entitled Slender Reeds, Sturdy Shoots: How Domes, Arbors and Fences Are Easy to Construct, Quick to Take Shape and Immensely Satisfying. The article describes how the structures are built and then discusses how these structures relate to gardening. He states: “Although Gale insists that she is not a gardener, she is an artist who weaves spaces out of living willow” (Christopher, 2006, 70). In the Fall/Winter 2006 of Vogue Living, Hamish Bowles discusses the gardens of Carolina Irving, textile designer and Vogue Living Style Editor in Springs, New York and he states:
“Inspired by France’s Le Prieure d’Orsan, where architects Sonia Lesot and Patrice Taravella have evoked extraordinary medieval gardens, Irving commissioned English landscape artist Bonnie Gale to create a garden pavilion from live willow saplings in the lawn between these colorful beds. Trained into a hemispherical room, this enchanting living structure provides leafy shade from the summer’s heat.” (Bowles, 2006, 196).

Figure 6 shows an image of this garden pavilion. In the summer of 2010, Jo Stealey, writer for Fiber Arts magazine wrote a profile on Bonnie Gale and her living willow sculptures. The article tracks the progress from willow basketry to living containers. She states:

“With the introduction of living material into her work, she increased the scale and initiated the production of living domes, arches, tunnels, fences and many other sculptural forms in the northeast region of the United States.” (Stealey, 2010, 32.)

She goes on to place the work in a larger context:

“Gale has redefined what basketry is and has moved into functional, ecofriendly, land art that defines and enhances the environment and involves the community. She continues to celebrate her passion for willow and push the boundaries of her work.” (Stealey, 2010, 33).

The significance of the last quote is a recognition that the living structure work of Bonnie Gale is constantly evolving and changing and at present has moved into the realm of environmentally friendly land art.

The October 2011 issue of the Landscape Architecture Magazine carried a plant profile on willow by Constance Casey entitled The Storied Willow and while discussing the history, folklore and current uses, it failed to mention living willow structures. There was one sentence in the article distantly related to the subject.

“We may not all want to start weaving baskets or making cricket bats immediately. It would be more interesting, though, to experiment with a living fence/hedge combo, known as a fedge, widely used in Europe.” (Casey, 2011, 34).

Overall, it has been shown that coverage of living structures has been sparse in the published media but the articles have had a broad range from a living dome to a unique garden design and also to schoolyard applications and private gardens. This range shows that the profession of landscape architecture does appear to be broad minded and there is hope for greater depth of coverage in the future as more structures are built in more diverse forms.
Future Trends in Landscape Architecture

There are many forces in the world that are creating pressures for new responses to emerge. As stated by Johnston and Wescoat in the tome entitled Political Economies of Landscape Change:

“The landscape is constantly changing, and here the agents of change are not only biological or chemical, but increasingly social. Shifting economic balances, changes in community structures, strengthening or weakening political power are all reflected in the works on landscape architecture, and indeed, landscape architecture influences these shifts...by inclusion or exclusion. Not all of these changes may be comfortable, for future landscape change can and will move in many directions.” (Johnston and Wescoat, 2008, 197).

Landscape architecture is uniquely positioned in the United States to take a lead in responding creatively. There are nine forces and trends that are discussed below, including urbanization; climate change; relation with nature and human health; energy issues; ecosystem services; biophilia and living architecture; green building; natural architecture and art in the landscape; garden design; and ecological urbanism, landscape urbanism and sustainable urbanism. All of them will have an impact or relationship with living structures. Living willow structures can play an important role in the solutions as will be discussed below.

Urbanization

One of the leading trends in the world is increasing population and increasing urbanization. On October 31, 2011, there was much publicity as it was expected that the world population would reach the 7 billion mark on that day. This figure needs to be put in context with the fact that the world population in 1950 was only 3 billion. It is predicted to reach 10 billion by 2100. This figure represents over a three fold increase in population in 150 years. The planet cannot support this quantity of population increase with regard to the current patterns of resource utilization. Population control has been discussed at the global level for many decades but implementation has been difficult as it involves curtailments of personal freedoms, conflicts with religious beliefs and consequences to social systems plus the demographics of aging populations. In addition, in 1999, the United Nations predicted that by 2030, over 60 percent of the global population would be living in cities. In the latest 2009 revisions, there is a now a staggering 69 percent of world population predicted to be living in cities by 2050 (United Nations, 2010).

Landscape architects will play a major role in balancing these forces of increasing urbanization and human health in cities with the health of the environment. More effective use of existing land in cities through redevelopment and rejuvenation of brownfield and marginal sites will probably lead to higher densities of development and greater efficiencies of energy resources. As Kellean Foster states in her book Becoming a Landscape Architect:

“Landscape architects will also play a key role in “greening” cities, such as designing meaningful and valuable open space systems. As cities become more dense and complex, there will be an increased need for places that inspire people, protect nonhuman biodiversity, cleanse stormwater and wastewater, as well as places for parks and recreation corridors.” (Foster, 2010, 260).

With increasing urbanization, there will be a need to use land more efficiently and to use resources sustainably. Living willow structures that provide contained living green interactive space in very small amounts of land can play an important part in the provision of natural environments in cities.
Climate Change

There is much evidence that the earth’s climate is changing which will result in changes to regional weather patterns, rising sea levels and more powerful, less predictable storms. Landscape architects are amongst one of the many design professions that will need to design for these changes and unpredictable events. Designs are evolving to deal with a certain level of flood waters but there is a lot more research and design that needs to follow.

In order to work with the issue of the emission of greenhouse gases from modern lifestyles and industry, especially carbon dioxide, there is growing interest in carbon sequestration. One of these methods is the storage of carbon in certain plant roots and soils. Willow is known for its carbon sequestration qualities. Willow is also a carbon neutral fuel when burned as a source of energy. Willow plants are well used in phytoremediation as a result of their ability to take up and store environmental toxins in roots and plant tissues (Thank you, willow.) It will be increasingly important for landscape architects to play an active role in environmental stewardship.

Relation with Nature and Human Health

Although landscape architects design parks and green spaces for public enjoyment, a deeper issue has come to the fore in the last two decades. Psychologists have been conducting studies as to the presence and even the “view” of nature on human health. The Kaplans (Rachel and Stephen), in their landmark 1995 book entitled The Experience of Nature: A Psychological Perspective, show that even immediate lowly grassy places foster tranquility and well-being. Over a period of twenty years, the authors sought to understand how people perceive nature and the benefits that accrue. As children, particularly, are restricted from playing freely in nature with found objects (such as sticks, stones and dirt) due to adult fears of attack or “dirtiness”, Richard Louv in his book Last Child in the Woods: Saving Our Children from Nature-Deficit Disorder, discusses the “criminalization of natural play”. As a result of these forces and the increase of electronic media interaction by children, there is now a recognized psychological disorder called Nature Deficit Disorder. Study after study has proven that direct contact with nature nurtures health, well-being and creativity. Louv argues for the spiritual necessity of nature for the young when young children are able to develop deep connections with the Earth and hence, adopt a life-long connection to planet health (Louv, 2005, 291–306). The recognition of this situation has led to the development of environment and ecology education in schools along with garden based learning in the form of schoolyard gardening, as discussed with Sharon Gamson Danks schoolyard transformation work earlier.

It has been shown that time spent in nature improves academic performance. Time spent in nature also combats childhood obesity as well as mental and emotional illnesses. Living willow structures are already designed in play spaces and will continue at a pace as schoolyard reclamation accelerates as a major trend of the future and the opportunities to reuse this land are realized. Living willow structures provide immediate nature-connections and green presence.

Although landscape architects do design healing gardens and restorative places, there is a far larger role that the profession could play in advocating more natural play areas and designing gardens for schools. Right now, it is educators and ecologists that usually design these children interactions. Within this field, there is such great potential for living structures to provide increased ecology and biodiversity, shade and play structures for children’s use and imagination, as advocated by Sharon Danks (Danks, 2002).

With regard to adults, they equally need access to nature and pleasant environments to walk and gain exercise. Footpaths can go a long way to encourage mobility. It has been shown that the presence of vegetation in city neighborhoods is likely to produce stronger ties between families. This in turn has an effect of reducing crime when eyes are on the street. All greenery will be valued and concentrated green living structures will be very desirable in urban areas.
Energy Issues

As oil supplies are further diminished, it will be necessary to develop a stronger agenda in alternative energy generation. Landscape architects can play a key role in encouraging and developing designs that move this agenda forward, as well as designing outside spaces that converse energy and water as well as using materials that are produced locally and are energy efficient. The rate of urbanization will add to this momentum and the call for higher density communities with good walking, recreation and public transportation systems. Landscape architects can play an important role in sustainable design. Much research has been done on the potential of willow as a source of biomass fuel (SUNY-ESF) and it is hoped that future forces will make this source more politically viable.

Ecosystem Services, Biophilia and Living Architecture

Along with the preceding discussion, there has developed in the last decade, the understanding that if one leaves natural systems alone, they provide countless benefits, called ecosystem services. Examples include how plants roots and soil store carbon; wetlands mitigate floods; vegetation and the underlying geology clean and purify water and trees clean the air. Increasingly, there is recognition by designers, at all levels, that nature should not be used to depletion but be considered a valuable asset and carefully used resource on which human health is dependant. This is a new cultural services paradigm. Landscape architects have the opportunity to encourage ecosystem respect and restoration.

In addition, there has arisen a movement called “biophilia”, the word meaning love of the Earth. In 2008, Kellert, Heerwagen and Mador published their book Biophilic Design and state in the preface: “This book immodestly aspires to help mend the prevailing breach existing in our society between the modern built environment and the human need for contact with the natural world” (Kellert, Heerwagen & Mador, 2008, vii).

The integration of nature into urban design and the design of buildings that connect people with nature is discussed in the book. Plants, animals and natural ecosystems are automatically an expression of perfection and humans are now aiming to distil the essence of the natural world into design so that humans can feel healthy, alive and connected. The future of human-kind is considered only viable when man reattaches to biological life and the life-generating geometry of the universe. Fourteen useful guidelines are given towards achieving more responsive human design, including issues of scale, symmetry, use of materials, geometry, interactions with nature and intimacy of design as well as a selection of pattern languages (2008, 77-81). Later discussions on biophilic design strategies include adding open space around buildings, maximizing naturalized plantings, providing living walls and green roofs on buildings, providing views of nature, maximizing daylight, and use of natural materials (2008, 329-330). I would argue that such suggestions are good but cosmetic and do not address the deeper issues of truly sustainable living architecture.

Separate from the biophilia discussion, there have been many architects who have proposed an architecture that transcends materiality. They have searched for a way to design buildings that express “soul” and connection to nature. Christopher Day (Day, 2006), in this book, Places of Soul, discusses architecture and environmental design as a healing art and describes a process of “ensouling” buildings. Material transcendence is expressed in spiritual terms. Frank Lloyd Wright was a master architect who gave soul to his houses through the simple technique of bringing the outside nature into the inside through careful placement of buildings to the site and a variety of sophisticated and interior design techniques of light and space and texture. Frank Lloyd Wright spent much of his life advocating for "organic architecture". Many of his renderings show vegetation "dripping" off the building, and gaps in the structure to either allow plants (trees) to pass through the building or light to reach the plants beneath the structure.
Christopher Alexander (2002-2005) has explored the subject of living architecture in his four-volume work *The Nature of Order*. He shows how living structure crosses over the line between animate and inanimate. In this way, deep nurturing connections are made between the human viewer and the building or nature. A level of transcendent sacredness and reverence ensues. Ultimately, the nature of reality can be questioned. Alexander proposes God is manifest in the natural geometry in living structure.

Tom Bender is a proponent of living architecture and bringing buildings to life:

“This architecture comes from a different place and culture than our currently dominant one. It is based on life-enhancing values, not greed. It is based on physics that extend into the energetic realms, not just the material ones. It is based in the awe arising from connection to the sacred. It’s just natural to build this way when we’re not divorced from the rest of Creation... Living architecture, in a culture aware of the role of life-force energy, fulfills a different role and holds a different focus than one in a materialistic culture. It focuses on place, not space—as our existence extends beyond the space-time realm. It focuses on relationships rather than structure, as dynamic interconnectedness, not unchangeable rigidity, is paramount. It focuses on meaning instead of aesthetics, as inner rather than surface characteristics are of central value.” (Kellert, Heerwagen & Mador, 2008, 314).

That the focus is on place and not space is very meaningful to living architecture and living structures as a truly live structure is all about making place first and foremost. Although this discussion on living architecture is focused on the current concept of making a building with inert materials to have a sense of soul, there is no reason why living architecture cannot actually mean buildings made of living green materials. Tom Bender goes on to discuss some of the facets of these newly defined energetic relationships, including beauty. Many find the living structures that I build to be beautiful, which is gratifying since this is what I seek to create. Beauty is actually a by-product of working in harmony with a beautiful material with a great deal of life-force energy. Beauty becomes an offering to spirit and a recognition of truth at a deep level. It cannot be placed in a box or packaged in anyway. The artist must have the freedom to work unhampered and freely to express the creative forces coming through in love. Every situation is unique. Living architecture invites, energizes, relaxes and connects. Living architecture is part of a living culture—a transformation to a nourishing and integrally connected universe with profound potentials. Can we reclaim our natural intelligence?

**Green Building**

The landscape architecture profession is well positioned to be a leader in the green movement. As stated by Kellean Foster (2010, 258-259):

“Today, being green means being innovative, as well as practical. Landscape architects are skilled at designing communities and spaces that not only respect the natural environment but often improve it. Landscape architects demonstrate time and again that green can have many benefits: besides being beautiful, it respects diversity, is better for the local ecology and sometimes costs less because the design works in concert with the environment, instead of fighting it”.

Green building involves a return to the consideration of nature such as how to take advantage of the sun’s heat and light plus storage and use of water. LEED (Leadership in Energy and Environmental Design) is a building rating and certification system of the Green Building Council system. LEED is the nationally accepted benchmark for the design, construction and operation of high-performance green buildings.

In the Fall of 2006, the U.S. Green Building Council issued a challenge to all green building professionals. With the intention of raising the bar of “sustainable design”, the Living Building
Challenge sets out targets for new building design. Buildings will generate all their own energy from renewable resource and capture and treat all their waste on site. Resources will be used efficiently. There are 16 criteria to be met which are performance based. The Challenge calls for buildings to reconnect to the rhythms and systems of the natural world. In inviting the industry to answer this challenge, the hope is to transform the meaning of true sustainability and to embrace a parallel transformation in architecture. As will be shown below, prototype living structures are being built in Europe as a way of building sustainably.

Green roofs and walls are being touted as a major solution to “greening”. They both mitigate the heat on buildings and green roofs provide better solutions for storm water runoff on roofs. They have both generated a new major industry providing all the extra paraphernalia and can appear as another consumer gimmick. In Europe, green roofs move beyond a bunch of sedums on a roof to developing complex ecological zones involving fauna as well as flora (Dunnett & Kingsbury, 2010). Green walls are harder to maintain and their economic benefit are dubious beyond aesthetic. In order to achieve true green and sustainable buildings, there is a long way to go. Living structures offer the benefits of green walls and open green roofs.

Natural Architecture and Art in the Landscape

Starting in the 1960’s, there developed a movement called Land Art or Earth Art. Land Art uses the land as the medium. The land is the material upon and within which artists create unique expressions. Ben Tufnell (2006, 15) states “Land Art is characterized by an immediate and visceral interaction with landscape, nature and the environment”. The engagement of the artist may be in the form of excavating, building, mapping or walking. It can be also defined as land sculpture. Taking the art to the audience is often in the form of documentation or photography. Land art is sometimes on a very massive scale such as the work of Robert Smithson in Spiral Jetty and Michael Heizer’s Double Negative.

Many artists relate quite specifically to nature and its elements, whether they involve change or not, such as the work of Andy Goldsworthy where some of his work captures the interface of natural forces on a man-made intervention. Patrick Dougherty builds magnificent interconnected nest type shapes with local woody material (often willow, if it is available). His works are meant to be temporary and taken down. His work has been called a modern primitive architecture as he uses sticks and young saplings. Whatever the context, his variety of forms are seamlessly interlaced with their surroundings. He has had several articles in Landscape Architecture magazine (Hines, 2005; Hammett 2001b). His book Stickwork just published by Princeton University Press, documents the evolution and development of his work.

Land Art has moved into a naturalism where nature is seen as a force in rapid mutation, yet still the force of all life. Environmental issues have sharpened the focus and technological advances have dominated our lives. So an elemental architecture or natural architecture has arisen to express the connection back to nature. The artists use humble elements and are at the mercy of natural forces. The observer becomes a willing human participant. Artists include Brubi and Babarit, Giuliano Mauri, Ichi ikeda, Jackie Brookner, Nils-Udo, Chris Drury, Olafur Eliaison amongst others. The work of Marcel Kalberer which is included elsewhere in this paper is also part of this natural architecture (Rocca, 2007) definition.

One can argue that the living structure work contained in this paper is Land Art. I would say that it is art, at least and growing art, in reality. The structures are also natural architecture. Figures 7 and 8 show two pieces of non-functional art created by the author. They are fun and dramatic. The Living Tree 1 is live and Tree 2: Spring Unfurling is not alive. Living Tree 1 aims to deconstruct the tree form and reassemble it in an unusual manner. Tree 1 consists of 60 pots of live willow, each covering a bent metal pole. The poles have different degrees of bend. The dormant live willows were planted in pots and forced in a greenhouse at SUNY-ESF for the March 2010 CNY Blooms Flower Show. The 60 pots were assembled into one tree form.
Tree 2 takes non-alive willow which cover poles in haphazard degrees of bend and then each pole was painted and also finished for an eventual outdoor installation. The purpose of art has always been to question reality and engage the emotions of the viewer. I wish to explore large scale land art with my work in the future. I draw a line between functional structures and those that are not functional or purely art. In my mind, planted living material has a larger goal, for the most part, than non planted installations. The larger goal is usually to make a permanent expression of shelter, furniture, definition and form. In all living structures, there is the understanding that the live material will change over time and those changes will be carefully monitored and controlled for the purposes of creating shape and space. So living art has a time element to it and in the case of arborsculpture discussed below, this time frame is often very long (at least ten years). Also due to the time element, it means that the living structures are usually permanently located at a site.

### Garden Design

Another trend is the role of garden design in the changing environment. Although, garden design in the United States is often absorbed into the work of landscape architects, many argue that they are not trained in sufficient depth in plants and planting design. With increasing urbanization in the future, the role of small intimate gardens will be of greater value to citizens. There have been a large number of newly published books that have titles related to sustainability, low energy and gardening in small spaces. Although, there are professional garden designers with accreditation and specific training in other countries, the United States is slow to embrace garden design as a profession. This may well change in the future. Important international garden designers such as Piet Oudolf have been cooperating with architects and landscape architects on large scale public projects such as the Highline in New York and Potter’s Field in London. As quoted by Tim Richardson in the December 2011 issue of the Garden Design, the Journal of the Society of Garden Designers in the United Kingdom:

"...planting design is fast becoming a much more important element that hitherto in cutting-edge landscape design internationally. Yet architects and landscape architects are
painfully aware that they are not equipped to provide this element in their designs - which is where garden designers might come in as collaborators... When architects realize that green roofs and green walls are a Noughties phenomenon — a green gesture that is already dated — they may start to think about the garden as the most ‘natural’ down-to-earth space for expressing their new found green credentials” (Richardson, 2011, 7).

Well said! In addition, European garden designers have always included art in their garden designs. The use of sculpture, bright color, spheres, canals and unique form and texture made with a range of materials have been present for decades. Art is often a centerpiece of a garden as seen at the annual Chelsea Flower Show in London. Living structures have also been included along with pleached trees, topiary and other tree manipulations in gardens. W. Gary Smith, an American landscape architect, has been leading a movement of using art to express design in the garden. He believes that art is a way of unleashing creativity in garden design (Smith, 2010). Besides using art to express design, he then encourages that the rhythms and patterns be expressed in installation art. Within this new role, garden designers will be more amenable to include living structures in their designs.

**Ecological Urbanism, Landscape Urbanism and Sustainable Urbanism**

All of the preceding discussion fits together with the latest discussions of urbanism in landscape architecture and the design professions. Charles Waldheim coined the phrase “landscape urbanism”:

“Landscape urbanism describes a disciplinary realignment currently underway in which landscape replaces architecture as the basic building block of contemporary urbanism. For many, landscape has become both the lens through which the contemporary city is represented and the medium through which it is constructed” (Waldheim, 2006, 11).

His definition means that the purview of landscape architecture has moved beyond parks and gardens to the very fabric of the urban city including freeways and abandoned industrial sites. Yet, the emphasis is on a horizontal exurbation. De-industrialization then provides landscape architects and urban designers with a new venue. In discussing ecological urbanism, Waldheim has described it as both a critique of and a continuation of the discourse on landscape urbanism. Mostafavi states:

“Ecological urbanism proposes to multiply the available lines of thought on the contemporary city to include environmental and ecological concepts, while expanding traditional disciplinary and professional frameworks for describing those urban conditions.” (Mostafavi, 2001, 114).

Mostafavi argues that increasing urbanization is having great effects on the health of humans and a workable sustainability needs to be found. He argues that the scale has changed and there is greater need for holistic approaches. Therefore, in viewing the fragility of the planet and its resources, there is an opportunity for speculative design innovations and new approaches. This requires a new sensibility. The new approaches need to address the retrofitting of existing urban conditions as well as provide plans for future cities. Density becomes important in the discussion of ecological urbanism with local urban food, good infrastructure and flexibility being built in.

All roads ultimately need to lead to sustainable urbanism, though, for a hopeful future. The human settlement pattern, beyond the consideration of individual dwellings, is seen as the crucial variable in the environmental solution of sustainability. Douglas Farr calls the emerging pattern of sustainable human settlement as “sustainable urbanism” (Farr, 2008). He defines it: “sustainable urbanism is an integration of walkable and transit-served urbanism with high performance building and high-performance infrastructure”. Lack of human contact with na-
ture plus car dependence and the wasteful use of land have caused humans and the planet much damage which cannot continue. This new form of settlement is high density, with local food and retail and with sustainable transportation and biodiversity corridors. Neighborhoods become sustainable with sound economic, energy and community design. He proposes 30 benchmarks and thresholds for this type of new design. He argues that a generational shift in thinking and attitudes will be necessary but he does show that it is very feasible and gives over twenty case studies of built projects around the world. Some examples in the United States of include Glenwood Park, Atlanta, Georgia; High Point, Seattle, Washington; Loreto Bay in Baja, California; Lloyd Crossing in Portland, Oregon and Coyote Valley in San Jose, California. His detailed case studies give practical applications of sustainable urbanism.

Living Willow Structures in the Past and Present

In order to document present living structures and elaborate on the potential of living structures in the future for the changing world, a discussion follows of how the structures are constructed. Three main methods are employed; namely, fedge, poling and arboriculture. Each of these methods will be discussed in turn. In addition, the grafting issue will be covered. Some major past and present builders of each form will be mentioned.

Fedge Method

In the late 1980’s, Ian Hunter in England started to design and build elaborate structures in school yards in northern England. Prior to that time, other nationalities such as the French and Germans were already extending their very strong willow growing and basketry industry into the application of outdoor woven structures. Ian created the Willow Tree Sculpture at the Rosendale Groundwork Trust in Rawtenstall, Lancashire with children from a local school in 1987 (Figure 7). Besides the structure, it also involved a willow charcoal kiln. This work was part of a larger effort to reintroduce traditional coppice crafts and willow basketry into the North West of England as part of Crafts and Environment Programme of regional environmental sustainability of Agenda 21, part of the Rio Summit in 1992. In 1987, the school children were involved in planting the willow for coppice with the notion that the trees were the teachers. Then basket makers and coppice workers were introduced and the living sculpture was started in 1988 and became the framework of the Tree of Life, an outdoor living classroom and environmental education project.

The Willow Tree Sculpture was the first of its kind and then at the “New Forms in Willow” conference in 1991 at Ness Gardens at the University of Liverpool in England, many major willow workers were present including Ian Hunter, David Drew, John McQueen, Gyonky Laky, Steve Pickup and Patrick Dougherty. As a result of this gathering, Steve Pickup who had started his business The Willow Bank in Gloucestershire, England in 1985, then developed the living fedge method. Again, similarly to Ian Hunter, his living structures in schools are funded through Sector 39 sustainable garden design, creating interactive landscapes for environmental education in schools.

The fedge method takes the unit of building as a piece of living fence. The word fence and hedge were combined to create the new word “fedge”. Many builders, however, do not use this more formal method and just weave willow rods randomly. The fedge method involves three parts to the construction: namely, uprights or stakes planted vertically at a prescribed spacing; followed a line of horizontal called “binder” to put the upright rods into the shape of the structure and finally the diagonal weavers. Steve Pickup produced a DVD video of this method of construction (Pickup, 2006).

The first decision is the shape and size of the structure. The ground is then prepared if rocky (to remove rocks) and a ground cover may be installed. A line is drawn on the ground of the floor.
The uprights are long vertical rods that are usually one year old and are inserted into the ground about one foot in depth. The recommended spacing by Steve of the uprights is 8 inches apart. These are planted on the footprint of the structure shape (Figure 10). The second step involves doing some pairing or twining weave horizontally at about waist height or 4 feet height from the ground in order to position the stakes into the required shape of the end product. On a dome or other circular shape, some large rods can be singly curved to the shape and the upright can be attached. The attachment is usually some stretchy cord, such as elastic. The uprights are secured at the 8 inch spacing to the horizontal binder (Figure 11). The last step of the three involves weaving sets of diagonal weavers into the area of the uprights below the binder. These diagonal weavers can either be inserted into the same hole as the upright or a hole in between the uprights (usually the latter). Starting at the thicker end of the rod, it is guided behind, in front, behind at a diagonal from one direction.

Figure 9: Willow Tree Sculpture designed by Ian Hunter, Rossendale Groundwork Trust, UK, 1987. (www.littoral.org.uk).

Figure 10: Uprights 8 inches apart and one foot deep (Author).

Figure 11: Horizontal binder (a) and diagonals inserted (b) in two sets (Author).

Figure 12: Diagonals cross on an upright and are tied (Author).
Usually all the diagonals from the first direction are planted and then a second set are woven from the other direction. It just so happens that the diagonals from the two directions cross each other at an upright in several tiers of height. It is then customary to tie, with stretchy material these diagonal crosses to the uprights (Figure 12). Live willow has the ability to self graft and will often self graft at these tied intersections, making the structure even stronger.

Jon Warnes published his book Living Willow Sculpture in 2000 in England. He covers the work of many builders, who, in general use a simplified fedge for the building of fences, tunnels, wigwams to elaborate bowers. Warnes’ speciality is the construction of living chairs (Figure 13). He shows a variety of designs of living chairs that are built and then planted in the ground. Vibe Gro in Denmark documents her living willow work using a modified fedge method (Gro, 2003). Her fences do not include the uprights but just the two sets of diagonals (Figure 15). The weave is quite open. The fence mazes are interesting and her domes and tunnels do include the uprights. Her sculptural huts, live willow balls and bird feeders are unique. Another Danish Willow worker, Jette Mellgren (Mellgren, 2007) has also developed a unique living fence with the fitched weaving technique (Figure 14). The horizontal fitching will not live and so will not impact the live willow growth. It would be interesting to observe how this design stands up over time.

My work with this method has ranged from fencing to arches to domes and beyond. The work can be viewed on the web site www.bonniegale.com and www.livingwillowstructures.com. Over 30 living willow structures and installations have been completed to date since 2004. I will mention three specific installations to show the type of design thinking that has occurred.

In 2007, a Mid Atlantic Arts Foundation, Artist and Communities grant allowed me to engage in a large scale community living willow installation, in conjunction with the Arts Council of Erie and the Lake Erie Arboretum at Frontier Park, Pennsylvania. Community groups were defined and a series of public meetings followed where the design of the installation was created. The design uses the “leaf” shape which is also the logo of the Lake
Erie Arboretum at Frontier Park (LEAF), a partnering agency, where the installation is located. The design involves three heights of “leaf/leaves”; a central 12 foot sculptural monument, around which are a series of radiating 6 foot arches in the leaf shape. These arches open into 3 foot high double leaf walkways. There are also radiating curved pathways to the exterior of the installation which mirror the curve of the nearby stream and the Mother Willow Tree which is a central anchor in the park. The original conceptual design was 50 feet square, but after “real life” considerations, the installation size was reduced to 50 feet by 30 feet. The community then laid out and built the installation with live willow rods. There was an unveiling ceremony in July. A community pruning maintenance session occurred in

Figure 16: Diagram of LEAF design, Erie, PA (50 feet x 30 feet) 2007 (Author).

Figure 17: View of Erie installation 2007 (Author).

Figure 18: Detail of center monument 2007 (Author).
September 2007. This installation represents community involvement which is common in my work. It also represents a thematic installation which has an organizing principle for the whole design. The multi-faceted design can be classified as community living art, a place for enjoyment and exploration. Figure 16 shows the plan. Figure 17 is an image of the growing installation, with Figure 18 showing the central monument.

Another interesting context for living structures has been the ongoing living sculpture work involved with the ecological restoration of a wetland in Cazenovia, New York. Starting in 2009, a series of tiered double living fences, potted structures and a tunnel were created in the Willow Patch, Cazenovia, in conjunction with SUNY-ESF and Cazenovia High School students. The Willow Patch is a documented location where the Liverpool, New York willow basket makers would come out by train to gather willow. The whole project is a multi-year willow bonanza with the restoration of the old willow beds, ecological repair and the development of community space centered on the willows on site. Living benches have been built along with living sculpture.

The latest fedge type installation involved 50 feet of living tunnel in Pierce’s Park in the Inner Harbor of Baltimore on Pier 5. Due to the visibility and use of this tunnel for local children,
the spacing of the stakes was much closer to 6 inches on the inward curve. Also, to move away from having a ridgepole where the pairs of uprights meet at the top, I designed a new method of bringing the stakes over the top on each side and then interweaving the rest of the length down the sides of the tunnel. This method gives a beautiful rounded top curve to the tunnel and creates a dense canopy. Figures 19 and 20 show the tunnel just as it was planted (the threat of Hurricane Irene was imminent, hence the fortifications). Figure 21 shows the structure just 17 days later with a fabulous amount of growth. These willow structures are always shocking how quickly they grow. Figure 22 illustrates the new method of side weaving that was developed on site.

In this fedge method of construction, where the willow is not planned to be extended beyond the natural length of the willow rods, as in the poling method below, then it is usual that the design of the structure is limited by the length of the rods. This means that at the time of construction of the structure, the whole shape and size of the structure is built and is final. The new growth of the willow rods will be trimmed off, except in the case of where some filling in may need to occur. This method usually uses long tall one year living willow rods. Overall, aesthetically, the fedge method gives a dense wall of green weaving and provides spatial containment.

**Poling Method**

A second method of construction is called “poling” which involves the creation of discrete poles of live material fastened together, usually at the top of the whole structure. Depending on the scale, these poles may or may not have a tubular metal core to define the shape. The willow rods on the pole will be fastened together along the length of the pole. This method has a very different look from the woven fence method. It appears very structural (Figure 23). This image is one of a series of two outdoor living rooms that were constructed by Bonnie Gale in 2009 in Bridgehampton, New York each 17 feet in diameter. In this particular structure, there

**Figure 23:** Poling Outdoor Living Room, Bridgehampton, NY 17 ft diameter 2009 (Author).
were no metal poles involved and the poling was made by tying just the willow together with cable ties. Consequently, the structure was limited to the height of the available willow.

Sometimes, this method is combined with fedging where the live poles create the structure and the fedging fills in. Very long poles can be constructed, far taller than the length of the live willow rods. In these situations, the annual new growth of the live willow rods will be trained onto the poles, hence increasing the “live” height of the structure. This can take many years, before the whole structure is green. In this method, there are fewer opportunities for the willow to graft between poles as there is less contact. In this situation, in 2010, in Southampton, New

![Outdoor Pavilion, Southampton, NY. Two views of the poling structure just as completed and before new growth that will be trained onto the roof. Showing windows and doorway. 18 ft x 9 ft x 8 ft tall. 2010 (Author).](image)

York, a complete metal structure was first constructed and then covered with willow which would not be planted in the ground and hence stay alive. The live willow was then planted in the ground and incorporated into the metal structure with a fedge planted all around the structure. It reached up to the top of the walls. Over the first growing season, the new growth was trained up to the ridgepole (Figures 24 and 25).

In the case of the use of a metal core and in cathedral type spaces, this method involves taking live rods and adding them to the pole incrementally so that it is covered. This will mean that those rods along the length of the pole that have been inserted above ground level will not grow and will die but still add to the look of the pole being covered. EMT pipe is lightweight and easily bent and can be connected with straight and bent couplings. The willow used in this method can be one year willow rods but in the larger cathedral type spaces, the rods are usually of several years’ growth. In Europe, willow from pollarded willow trees along community boundaries and fields provide a free or cheap source of material. The longer and thicker material may well be branched but allows for a thicker covering of material on the poles which is appropriate for the scale of the construction.

This use of metal poles allows a great range of living shapes to be created. Without the structure and shape that the metal cores afford, it would not be possible to obtain the shapes and the regularity of them. The use of added lengths of poles beyond the natural height of the rods allows large and cathedral spaces to be created as well as an unlimited range of shape and spatial containment. Naturally, there are still some limits to how the willow will grow but it has been found to grow with the rods out of the vertical, horizontal and even pointing downwards. The extension of the height of the structures and the use of poles for form formation is one of the keys to the potential of live willow to be used in future landscape architecture projects.
Marcel Kalberer, a Swiss architect living in southern Germany is a master builder of this poling type of structure. He has written two books on this subject, the main one being Das Weidenbaubuch 1999 (Building with Willow) and Grüne Kathedralen 2006. The latter book shows a great range of cathedral structures, some with tenting and also futuristic architectural conceptions. He has built over sixty of these large scale structures through his company called Sanfte Strukturen (Soft Structures). He has an immediate group of helpers and then the local communities become greatly involved with often hundreds of volunteers. He describes his work as “living architecture”. His living architecture is then a process involving the social interaction of community volunteers as well as the natural growth of the living willow and the change that occurs over time. Marcel objects to the use of machinery and only man/women/power and pulleys are used. Often giant bundles of willow weighing 800 pounds are lifted into place. The social process of building then becomes one where the volunteers become in touch with their own physical strength. His structures are very large, using metal poles, often several hundred feet long and up to 50 feet tall. The web site is www.sanftestrukturen.de which shows the great variety of structures that have been built.

The first structure was planted in 1985. In 1988, he developed the technique of tying the bundles of willow using ancient Sumerian reed construction in Mesopotamia (Figure 26). The so-called Mudhif buildings are made of reeds branches, which are bundled together into stable arches. This technique is about 6000 years old and is still used today in Iraq. It is no exaggeration when one looks at these buildings that the original form of human architecture in Gothic cathedrals follows the same design concept. Willow rods or thicker poles are taken and are bundled into thick columns, beams and arches, allowing for the construction of large palace and cathedral type spaces. Marcel’s constructions are located in Germany, Sweden, Belgium, Poland, Austria and Switzerland.

Figure 26 (top-left): Auerworld Palast, Auerstedt diagrams of growth (www.sanftestrukturen.de).

Figure 27 (top-right): Sumerian reed knot tying technique (Author).

Figure 28 (bottom-left): Plan and section of Auerworld Palast (www.sanftestrukturen.de).

Figure 29 (bottom-right): Auerworld Palast view (Author).
One of his most frequently cited structures is that of Auerworld Palast (Other World Palace) in Auerstedt, Germany. It was built very fast with over 300 volunteers in March and April 1998. It is 25 meters wide (82 feet) by 7 meters high (23 feet). Marcel states (on his website):

"While the construction was a social event, the Palace itself would soon be used as a center for community festivities. The full moon events are legendary and have already drawn more than 80,000 visitors from near and far. Every event has its own character due to changing cultural activities and light installations. As the first Living Willow Palace, it became a very welcome and necessary tourist attraction in the sleepy countryside between Weimar and Naumburg. Today, the same world palace is called "Mother of all Willow-Palaces". (www.sanftstrukturen.de).

The drawings of the structure (Figures 27 and 29) show how the growth is likely to develop. At the ten year anniversary, it was declared to be in full growth. As Marcel is an architect, his designs are all drawn in great geometric detail and models are made. Figure 28 shows part of the structure in the winter of 2010. His designs and constructions are fabulous. Marcel’s constructions also have a deeper meaning of nature-inspired creativity and community celebration in the flow of life. So many of his constructions are for community celebrations with a stage included in the construction.

In 2010, he built his first structure in the USA at the Museum of Outdoor Arts in Englewood, Colorado. Entitled Weidenblume or "Willow Flower", it is a permanent, site-specific, living willow sculpture. It is the first American project by Sanfte Strukturen. The piece measures 23 feet (7 meters) high and 45 feet (14 meters) in diameter. Besides the main space, there are five niches of 13 feet in diameter. It took over 1000 willow poles and 200 meters of three quarter inch steel tube as well as 3000 meters of 4 mm of polypropylene rope. The structure took three months to complete and the author was present.

**Arborsculpture Method**

The third method of construction is entitled arborsculpture. This is the title of the book by Richard Reames (2007) where he defines it to mean:

"Arborsculpture is the art and technique of growing and shaping trunks of trees and other woody plants. By grafting, bending and pruning, the woody trunks and or branches are grown into shapes either ornamental or useful. Similar to espalier and possibly including some topiary, the word is a conjunction of the words arbor (Latin for tree) and sculpture."

This form of construction involves the whole living tree that is manipulated to grow its shape according to jigs, grafting, pruning and other devices. The manipulation of living tree trunks becomes a medium of artistic expression. The book Tricks with Trees (Hicks & Rosenfeld, 2007) has a good summary of the variety of methods.

There are a great number of modern arborsculpturists the world over. As the aim of this thesis is not to provide a complete survey on the subject, then only certain arborsculpturists will be covered. Those who have been chosen are considered to best illustrate the potentials and visions of the
movement. Certain arbor artists have also been excluded from this section as their work best highlights visionary practices for the future and these include Arthur Wiechula, Konstantin Kirsch and Mitchell Joachim. The history of this subject is ancient and will not be covered here. Certainly, the established methods of pleaching, espalier and topiary are closely related forms of tree manipulation. However, in the early twentieth century, John Krubsack (1858-1941), living in Wisconsin, had a vision to create a chair that would be better and stronger than one made out of machined wood. He started with elder seeds planted in a pattern for his chair. After three years, he built an enormous framework on which 28 young box elder saplings were grafted and bent and grew into his finished chair (Figure 30). All the saplings were carefully tended and grafted to give a comfortable chair, it took him a total of 11 years to grow the chair. After 10 years, he cut all the trees except for the four legs. This chair dubbed, "Chair that Grew", was exhibited at the 1915 World’s Fair in San Francisco. He never built more than this one chair but was able to show the feat that he had accomplished.

In the present day, several well known arborsculpturists continue the work of furniture making using jigs and frames. Doctors Chris Cattle and Lois Walpole in England grow stools, chairs, wine racks, coat hangars and other forms. Both have a desire to make a difference regarding design, environmental education and demonstration.

Probably the most important builder was Axel Erlandson (1884-1964). Reames quotes (2007, 55):

"No other figure today or in known history went so far in demonstrating the potential that trees have to offer to the art of arborsculpture. With only a fourth grade education and a strong will to teach himself, Axel Erlandson’s work “set the bar” for all aspiring arborsculpturists".

Figure 31: Basket Tree by Axel Erlandson (Author).
Figure 32: Four Legged Giant by Erlandson (Author).
Over 55 unique, shaped and grafted trees eventually graced the grounds at his famed Tree Circus, the roadside attraction that he opened in 1947 in Santa Cruz, California. One early example was The Poplar Window made with ten poplar trees proposed in 1928. His wife did not believe that it was possible but he proved her incorrect. It involved an elaborate gothic window with all the ten trees merging at the top. Many of his pieces took at least ten years to complete. However, the surviving trees have continued to grow and often some of the twists and designed openings have since grown together.

About 40 of his initial collection reside in Gilroy Gardens, California. The designs grown with sycamore were his most successful. The Basket Tree (Figure 31) was built with 6 sycamores that were grafted with 42 connections. It is fabulous! The Four Legged Giant is his oldest surviving tree (Figure 32). Erlandson kept his methods a secret and when asked how they were created he said that he ‘talked to the trees’. In retrospect, I am sure that he did. Wilma Erlandson, the daughter of Axel published a small booklet in 2001, entitled My Father Talked to Trees in which she describes the history Axel’s work and include fine examples of the trees (Erlandson, 2001). Richard Reames (200, 75) has studied his methods and states:

“For tree stock, Axel would collect cuttings or start with seeds. He would plant the trees he needed and build a frame from scrap wood that was strong enough to hold trunks and branches in the position he wanted. If a tree would start leaning, he’d correct the problem with wires stretched from a stronger tree to a metal rod bent into a hook to provide and anchor point on the leaning tree. The wire was pulled tight to straighten the leaning tree. These wires and metal bars, evident in many old photographs, were also used to protect the trees from wind damage...Grafting was the essential technique Axel used to perform his magic. To protect his grafts and hold them in place, Axel wrapped them in cloth until they healed...Axel sometimes used pieces of metal rod to hold parts of his trees in the correct position after the wooden frame was removed. In some cases, the rods were sawed off when no longer needed and in other cases, they were simply left in place.”

Erlandson was also involved in very aggressive pruning so that all unnecessary growth that did not benefit the designed shape was removed. Erlandson's work is so important in that he actually left his work to be viewed. He did have regrets at the end of his life that he had not passed his knowledge on to others and realized that the limit of his life span curtailed the continuing exploration of his new ideas. He clearly believed that the potentials of tree manipulation went far beyond what he had accomplished. He knew that his work was extraordinary and due to the time to see fruition, he wished that he had started earlier.

Figure 33: Arbosculture by Richard Reames (Author).

Figure 43: Ficus House, Okinawa, Japan (www.arbor-smith.com).
Richard Reames grew up in the mountains near Santa Cruz, not far from Tree Circus. His love of horticulture and botany led him to experiment with trees. In 1995, Richard Reames published his first book entitled How to Grow a Chair (Reames & Debtol, 1995). In this book he shows how to start with ten unbranched young saplings planted in four groups and with the use of grafting, metal bar and wire ties, the saplings are forced to grow into a chair shape. In 2007, he published his Arborsculpture book and documented a lot of his research. Today, he builds chairs, tables, gazebos and outdoor rooms for clients. Figure 33 shows an early arborsculpture using poplar trees. Reames is building a living bridge using five young poplars that he has trained horizontally by tying them to wooden stakes in various places across a stream. The tips have been allowed to grow upward. The horizontal trees will thicken and the stakes will be removed. He is developing many true tree houses at his home in Williams, Oregon.

A very beautiful example of an arborsculpture is the Ficus House on the island of Okinawa, Japan (Figure 34). Little is known about the builder. This building has a truly green roof!

**Grafting/Inosculation/Inclusions**

In the discussion of the methods above, there has been mention of grafting. In the fedge method, the tying of live rods together usually results in natural grafting. It is not guaranteed to occur but it does occur much of the time. There is no conscious removal of bark. In arborsculpture, the formal method of grafting is used as this is critical to the method. Grafting is a process that trees do naturally. Roots as well as branches naturally graft. Inosculation is the term given to the joining of vascular systems. Axel Erlandson used this technique extensively. Trees with thinner barks appear to self graft more readily.

In the fruit tree industry, it is standard practice to graft one kind of rootstock onto another variety of tree to obtain the desired qualities of both, for example dwarf rootstocks keep the apple trees smaller in size. In fact, several varieties of fruit can often be grafted onto one rootstock as long as the species are compatible. This type of grafting is called “detached scion graftage” and involves either apical (tips), bark or root grafting. More information on these types of grafts can be found in the textbook Plant Propagation (Hartmann et al, 2002). With regard to the goals of arborsculpture, the “approach” graft is the easiest to perform and is used extensively. In approach grafting, two independent self-sustaining plants are grafted together. Three types of approach grafts can be distinguished (Hartmann et al, 2002, 486) and they are named: sliced approach graft, tongued approach graft and inlay approach graft (Figure 35). Spliced approach grafting is the usual method in arborsculpture and is best performed when the sap is flowing. It is simply removing (with a grafting knife) a slice of bark away from the two trees to be joined. The removal of bark allows the cambium layer of each of the trees to be in intimate contact. This contact is wrapped tightly with tape to prevent drying until the graft is successful. The creation of this wound starts a process of callus material being generated by both trees in order to seal the wounds. The trees will sort out their linked vascular systems and continue growing in a normal way, adding growth rings until all evidence of the wound virtually disappears.

![Spliced Approach Graft](image1)

![Tongued Approach Graft](image2)

![Inlay Approach Graft](image3)
With regard to the tying of live willow together without making a wound, Reames (2007, 182) states: “Simply wrapping different parts of the tree together tightly can accomplish the same thing. It takes longer than a wound-joined graft, and a bit of bark may be included in the graft, which can make the joint a little weaker.”

I have found that in the tied fedge method, the graft does not always take. Figure 36 shows natural grafts at the joins of the uprights and the two sets of diagonals tied with black elastic in the fedge method of the LEAF installation in Erie, Pennsylvania discussed earlier. Although one is told to remove the elastic so that the willow is not strangled, the reality of the situation is that the willow easily grows over the impediment. Experiments show that when two branches graft together the angle where one branch crosses the other has a marked effect on sap flow. It has been found that the more acute the angle, the more efficient and successful the graft. It is important to immobilize the areas of the grafting while the graft is taking. When multiple trunks are being joined, both sides of the graft may grow in a balanced way. The tree will have the choice of which path to take and will usually take the shortest rout from root to crown. As seen in the work of Axel Erlandson, he was able to achieve magnificently balanced growth in his creations, Basket Tree, for example. It is unclear if the results that he achieved were due to the species, the design of the grafting or the artistry of the man himself. The latter is probably the most important factor. One feels that he used extreme care and attention to his work.

It is also necessary to mention the role of inclusions. Inclusion means that an object is placed in a growing tree and the tree will grow around it. Then, the tree will literally include the item into its growth and may even conceal it. It has been noticed that when a live tree comes in contact with a foreign object, that it will increase in surface area, as if in self-defense. It is this increase in woody matter that creates strength in the inclusion. Examples include a bicycle left in the crock of a tree on Vashon Island, Washington (Figure 37). Richard Reames has trained young saplings in the sleeves of shovel heads and hence achieved new handles. Faucets can be included and so it appears that water is coming out of the tree. Reames (2007, 188) states:

“A tree’s natural ability to include objects presents the aborisculptor with a whole new field of potential. As far as tree health goes, any deadwood then becomes

Figure 36: Natural grafts of joins tied with elastic, LEAF installation, Erie, PA (Author).

Figure 37: Bicycle in the Tree Inclusion, Vashon Island, Washington (www.arborsmith.com).
included in a tree’s growth, a commonly occurring situation, and is much more damaging to a tree in the long term than metal or glass. Deadwood provides a platform for bacteria to gain strength where glass and metal do not”.

A very key point to make is that there is great potential to use this technique in living houses as electrical service, plumbing, windows and platforms can be contained inside living trees by the method of inclusion. This concept will be discussed further in the next section.

**Living (Willow and Other) Structures for a Future Changing World**

The discussion now moves to the potentials for the future by discussing three areas in turn. The first area is the exploration of the work of visionaries, namely, Arthur Wiechula, Konstantin Kirsch, Luc Schuiten and Mitchell Joachim. Secondly, some futures forms that are being built at this time will be discussed including The Patient Gardener in Milan, Italy; Living Root Bridges in India and Baubotanik in Germany. A discussion then follows on future locations for living willow structures and future landscape architecture forms.

**Visionaries**

**Visionaries: Arthur Wiechula, Germany**

At the same time as John Krubsack was building his living chair in the United States, Arthur Wiechula (1868–1941) in Germany was experimenting with living buildings and homes. He published several small books, including *Wachsende Hauser aus Lebenden Baumen Entstehend* or *Developing Houses from Living Trees* (Wiechula, 1926). He also wrote a small brochure translated to *Timber Buildings Under Co-operation of Nature* a year after the above was published. Arthur Wiechula had been inspired by reading the works of the mystics, Jacob Lorber and Emanuel Swedenborg. With their work as a starting point, Arthur extrapolated how he thought one would be able to grow fences, bridges and buildings.

According to Wiechula, it was a rather roundabout process to grow trees until they were a certain height and then cut them down to saw into beams and planks and then put them skillfully together again to make houses. Wiechula started from very simple building techniques. He exploited the capacity of branches and trunks to be grafted and fused with one another during growth. His philosophy was stated (Wiechula, 1926):

> “If it were possible to grow wood in such a way that it already constituted walls during growth, walls which could be cultivated to make buildings, we could save on this lengthy process and would be able to use very young wood for construction”.

Wiechula was interested in a much wider concept than Krubsack. He was interested in truly living buildings. The illustrations in the following page illustrate his visionary buildings. As a German engineer for Culture and Horticulture, his work was part of a revolutionary movement, called the Charismatic Era and he formed the Nature Revolutionary Construction of Berlin which developed a patent on nails with a backing washer that would accelerate the approach grafting of trees. The Society also offered for sale the prefabricated wall panels grown by Wiechula’s methods. His living buildings were not well cared for and were damaged by cold weather. He never built a living home, but he grew a 394 foot wall of Canadian poplars to help keep the snow off of a section of train tracks. Figure 38 shows his ideas for the manipulated growth development of ‘kit’ parts of buildings grown in plantations, including doors, windows and supporting structures. His illustrated ideas have inspired many other artists to attempt to grow living homes out of trees.
He did advocate a series of linear V-shaped cuts to aid in the bending and curving of tree limbs. Reaction wood (tension and compression wood) would then soon close the wounds to hold the curves. This method has also been seen in other work.
Arthur Wiechula did include his ideas for living fences and living walls through the filing of patents. This is amazing material. Translations into English are included below. The patent 459870 relates to the creation of living walls (Figure 39). He is proposing that a series of metal rods or wires are used at regular intervals vertically on the trees which will alternate either in front or behind the tree limbs. In this way, the wall is kept rigid and vertical and the trees will grow to include the metal rods. The third drawing shows how the individual limbs will relate to the metal over time to be absorbed totally into the trunks. There is no evidence that this method was ever constructed.

**Figure 39:** Living Wall Patent by Arthur Wiechula (Wiechula, 1926) with translation into English.

Patent 386940 (overleaf) relates to the creation of living fences. In Figure 40, from the two trees (α, f), branches are woven across the space formed by the triangle in order to fill in the triangular space. Part 3 shows more trees involved in the interweaving and the fourth diagram shows the end product. These drawings are stylized, as seen with his earlier drawings of houses and it is unfortunate that they were not built. In this patent, he places emphasis on the advantages of living fences over ones with non-living wood that will rot over time.
Overall, Arthur Wiechula offers us much evidence of his visions through his books and drawings, as opposed to Axel Erlandson who left no written evidence of his methods. Wiechula’s ideas have merit and it would be valuable to take these ideas and experiment with them over time.

Translation: Wiechula-Patent #386940

Original text: “Patent claims:

1. Protective fence against snow, made out of woven plants, characterized by plant rows (a, f) which sprouts are woven into surfaces (g, h) and are connected through common woven seams.

2. Protective fence against snow from claim 1, characterized by the surfaces (g, h) of plant rows (a, f) being connected through individual sprouts (k) or sprouts (k') from connecting plants (d, e).”

If branches and twigs are woven into surfaces, it will be easy to erect fences made out of these woven areas. These fences have an advantage over regular fences that they don’t rot with growing age but rather that the parts dug into soil will root and the whole fence will rather grow than rot.

Patent claim: woven fence characterized by weaving of fresh plant parts still growing above ground for the purpose to build a fence out of these surfaces that will independently root and therefore will not be prone to rotting.

**Figure 40:** Living Fence Patent by Arthur Wiechula (Wiechula, 1926) with translation into English.
Visionaries: Konstantin Kirsch, Germany

Moving to the realm of living houses, Konstantin Kirsch in Germany has contributed significantly to the dialog. He published his book Naturbauten or Living Architecture in 1997. He was inspired to experiment with growing houses from living trees and following some of the pioneer work of Arthur Wiechula. His first successful Ash Dome house was created with 1,350 3 year-old bare root ash trees planted at the spacing of seven trees per foot. This structure is designed to have 7 round rooms (5 meter in diameter) of walls with the saplings interwoven diagonally. It also includes an interior court and a bathroom (Figure 41). He uses screws to the joints of the diagonal crosses as well as metal clips and rubber ties. He imagines that the walls will eventually close up (after 20 years) and has already planned for the location of electrical outlets, by introducing inclusions. Windows are made by removing part of the living wall. He also has a Linden house with 700 trees and three rooms. With his interest in permaculture, he has planted food crops such as hazelnuts on some of the structures. www.treedome.com is his web site which shows the great variety of projects in which he is engaged including other domes and rooms made with hazel, mountain ash, beech, willow, pear and poplar. A video of his Ash Dome with English sub titles is available on the web site.

It is interesting to note that Reames and Kirsch (who are friends and have influenced each other) both use the young sapling method for the building of a living wall for a true living room. The saplings are then allowed to grow into mature trees using arborsculture with screwed grafting. This process can take at least ten years. The author uses instead one year long rods woven in the fedge method which the author believes provides a more uniform and faster growing product. Further research will continue in both methods and the results will come apparent over time.

Visionaries: Luc Schuiten, Belgium

Luc Schuiten is a visionary architect from Belgium. He imagines a world future that is ecologically sound and relates nature with invention. Since the late 1970’s, he has developed a body of work based on his understanding of architecture as a living system. He has created a new form of building called “archiborescence” (architecture plus aborescence). Nature becomes an ally for the development of a long lasting society. In his own words:

“The habitats of this city are made up of a vegetal mesh produced by the roots of a strangler fig tree which has grown up around a host tree. This fig tree may grow so tall that high buildings can be built into it. The constitution of this tree, which is made from roots which are joined onto each new intersection, offers a stable and resistant structure for any building. The outer walls of the dwellings are made from biotextiles, comparable to the substances used for silkworms’ cocoons or spiders’ webs. These semi-transparent materials can also capture solar power to supply the energy required for heating and electricity. People move around within the city using footbridges which overhang the uncultivated plain, thus allowing the natural cycles to continue. The soil can be left loose, and the host trees can be
irrigated and nourished by nutrients produced by the decomposition of organic waste.” (www.vegetalcity.net).

Figure 42: The work of Luc Schuiten (image left, book cover on the right) (www.vegetalcity.net).

Although his work has a very utopian and even science fiction feel to it, it may well be the radical change that the world needs in order to survive. At the heart of his designs for habitat, is the living tree. He, therefore, adds to the dialog of living buildings.

Visionaries: Mitchell Joachim, USA: Fab Tree Hab

Mitchell Joachim is a visionary in ecological design and urbanism. He is an architect, based at MIT, part of the Human Ecology Design team. He is co-founder of Terreform One, a non-profit organization for philanthropic architecture, urban and ecological design. The Fab Tree Hab is his design for a house made from living trees. He defines it as a “living structure single family home with an encompassing ecology”. He states:

“So what's a technology that will allow us to make ginormous houses? Well, it's been around for 2,500 years. It's called pleaching, or grafting trees together or grafting inosculate matter into one contiguous vascular system. And we do something different than what

Figure 43: Fab Tree Hab concept (top) and stages of growth (bottom, www.arcinode.com).
We did in the past. We add kind of a modicum of intelligence to that. We use CNC (Computer Numeric Controlled) to make scaffolding to train semi-epithetic matter, plants, into a specific geometry that makes a home that we call a Fab Tree Hab. It fits into the environment. It is the environment. It is the landscape, right. And you can have a hundred million of these homes. And it's great, because they suck carbon. They're perfect. You can have 100 million families, or take things out of the suburbs, because these are homes that are a part of the environment. Imagine pre-growing a village — it takes about 7 to 10 years — and everything is green.” (www.ted.com February 2010).

He argues that these dwellings then become fully integrated into an ecological community. They are composed of all living nutrients and water and metabolic flows are circulated symbiotically within these homes with zero waste. The self grafting trees become the load bearing structure and the branches form a lattice for the walls and roof. He amplifies his design:

“Weaved along the exterior is a dense protective layer of vines, interspersed with soil pockets and growing plants. Prefab scaffolds cut from 3D computer files control the plant growth in the early stages. On the interior, a clay and straw composite insulates and blocks moisture, and a final layer of smooth clay is applied like a plaster to dually provide comfort and aesthetics. Existing homes built with cob (clay & straw composite) demonstrate the feasibility, longevity, and livability of the material as a construction material. In essence, the tree trunks of this design provide the structure for an extruded ecosystem, whose growth is embraced over time.” (www.archinode.com).

The homes are naturally self-renewing through the seasonal changes and could add the concept of forest renewal in an urban setting. He includes John Todd’s concept of the Living Machine with water being an integrated and life sustaining system of collection, use and recycling with acquaculture incorporated. The houses are solar, providing their own heating and cooling and have composting toilets. The living house is designed to be edible, providing food to some organism at each stage of its life cycle. He calls the Fab Tree Hab as one of “slow farming trees.” Joachim argues that a completely ecologically sustainable structure needs to be within a revised system of cost benefit analysis where the environmental benefits over a longer period of time are calculated.
The new living home fits symbiotically into the ecology. With regard to the "green" movement, he comments:

“Although many individual and collective efforts towards 'sustainable' or 'green design' of buildings are apparent internationally, derivative design cannot address the underlying systemic nature of sustainability (emphasis added). Fixing pieces of a puzzle fails to address the interplaying complexities of the whole, and innovation is stifled by the need to work within given contexts. Lack of certainty in cause and effect is often cited as a reason for not developing ecologically sound practices, most notably with green house gas reductions and improvement of indoor air quality. However, the precautionary principle implies that protection should be embraced deliberately even in the face of uncertainty. Thus, instead of incorporating materials that may impart less impact to the environment and human health (impacts which may remain uncertain in extent), the Fab Tree Hab design seeks to protect and embrace the ecosystem as a source of sustainability in the built environment. Just as the modern biotechnology revolution owes its existence to the intelligence in ecosystems at the molecular level, sustainable technologies for homes can also benefit from biological, natural systems; however, starting at the molecular scale is not necessary. Rather, as the intention of this design explores, lumber maintained in its macro, living form becomes a superstructure (emphasis added).” (www.archinode.com).

In conclusion, Mitchell Joachim and his team are providing a holistic solution to ecological sustainability in the Fab Tree Hab. He is working on a prototype building. This work is cutting edge and is applauded for providing a solution using living trees.

**Visionaries: Mitchell Joachim, USA: Willow Balls**

Another use of living structure, designed by Mitchell Joachim and his team, involve living willow balls to be used as ecotourism dwellings. The willow balls are designed to be prefabricated units with a system of gray water, composting toilets and solar powered lighting. Apparently each ball should weigh less than sixty pounds. The prototype geometry of a wooden template to support the live willow while it is grafting to the shape is shown in Figure 46. The willow was planted and set up for grafting in 2011. Figure 47 demonstrates the concept of the willow balls.

![Figure 46](www.archinode.com) **Figure 46:** Template for willow ball wall (www.archinode.com).

![Figure 47](www.archinode.com) **Figure 47:** Willow ball ecotourism concept (www.archinode.com).
Future Forms

Future Forms: The Patient Gardener, Italy

A brand new arborsculpture project was started in October 2011 in Milan, Italy and is expected to take 80 (eighty) years to complete. During the weeklong MIAW2 workshop by Politecnico di Milano in Milan Italy in October 2011, Stockholm-based Visiondivision served as guest professors and worked closely with students to generate new ideas of green design. The guest professors conducted an exploration with students to consider the impact of the fast-paced lifestyle on ecology and environmental issues in architecture. The title of the project is The Patient Gardener as patience is the main concept of the design. The notion is to help nature grow in a more architectural and useful way through living architecture.

The structure consists of ten Japanese cherry trees which are the main building material for the construction of the two-story retreat. Bending, twisting, pruning, grafting, braiding

Figure 48: Concept visualization (Visiondivision).

Figure 49: Sketch of proposed arborsculpture methods (Visiondivision).
and weaving are the methods to be used to create the structure and the stairs to the second level. The trees were planted around in an 8 meter diameter ring. A six meter temporary wooden tower was built in the center which will serve to guide the growth of the structure through the use of ropes. Four of the trees will act as two pairs of stairs to the future upper level. On the structure, a pattern of wood will be grafted in, leaving two spaces between the trees as entries/exits and the rest will be closed in an ornamental patterns with branches.

Time is an essential part of the project, for as the trees begin to grow, their branches will form a dome when they reach the tower, and then shift direction so the final form will be an hourglass. Also included in the design are a table and four living chairs made of plum trees as well as sod furniture and a future sod platform. A harvest of fruit will be a by-product of the design. The architects created a maintenance plan for future gardeners to use. Visiondivision explained “In about 80 years from now, the Politecnico di Milano campus will have a fully grown building and the students will hopefully have proud grandchildren that can tell the story of the project for their friends and family.”

The Patient Gardener is a bold and exciting project. It demonstrates innovative architectural work in arborsculpture. Criticisms have been leveled with regard to the forces that will be put on the trees and whether successful grafting will be possible. Only time will tell. The arborsculpture community will learn from this project and there is gratitude that the project is a daring experiment. The 80 year time frame is not daunting to the designers and so The Patient Gardener is a true patient living structure.

Future Forms: Living Root Bridges, India

In Cherrapunji and Meghalaya, India, there are many living bridges made out of the roots of *Ficus elastica*, the strangler fig tree. Cherrapunji and Meghalaya are some of the wettest places on earth and for centuries, the long side roots are able to be woven horizontally across rivers.

Apparently, betel nut trunks are used to guide the roots to the other side of the bridge where the roots are allowed to root. These bridges take up to 15 years to be functional and are very
strong. As they are alive, they become stronger over time and some may well be over 500 years old. The art of interweaving the roots is a continual process that is passed down through the generations of families. These living root bridges show a further example of sustainable living architecture.

**Future Forms: Baubotanik, Germany**

The Research Group Baubotanik at the University of Stuttgart’s Institute of Theory of Modern Architecture and Design announced in September 2009 that they have opened to the public the first live tree “baubonatical” tower. The tower was designed to test the capabilities of living willow tree architecture. Baubotanik can be defined as a mixed design of living plants and conventional components. Carrier systems, handrails and other technical components are inserted into a system of young woody plants. When the trees are large enough to be load bearing then the structures may be removed.

The living tree tower is nearly 9 meters high with a base of 8 square meters and is made of hundreds of white willow (Salix alba) trees. Some of these trees are rooted in the ground but others are planted in containers in the temporary steel scaffolding. The initial willow saplings were only two meters tall. Double plants make rhombus crossings which are securely joined with metal. As shown with the arborsculpture projects earlier, the principle is that similar plants can be grafted together to make one structure. All of the willows will graft together to create one very strong functional tower. The new growth will

![Figure 52: Baubotanik Living Tree Tower, Germany, showing concept (L) and built project (R) (www.bureau-baubotanik.de).](image1)

![Figure 53: Structure of Tree Tower (www.bureau-baubotanik.de).](image2)

![Figure 54: Baubotanik Forest rest Stetten bridge (a), beach pavilion (b), and Baubotanik Hartenholm light tower (c), www.bureau-baubotanik.de).](image3)
be woven into green walls. When the willow structure is strong enough, the steel scaffolding will be removed, in approximately 8 years.

The tree tower is, however, only one of many other live baubotanik structures that have been built through this program. The other structures include the first platform in Olen, a pavilion in Stuttgart, a five-towers structure in Mainau, a residence in Freiburg, a two-story structure in Wald Kirchen, a beach pavilion in Überlingen, the first bridge prototype in Forest Rest Stetten and a lit tower in a garden in Hartenholm. Figure 54 (above) shows a variety of these structures.

The Tree Wall is a vegetal modular system (with its own contained irrigation) that can be sold for sound barriers and walls with a choice of sizes and crown types. The project LiloRann proposes the growing of invasive tree structures in the deserts of northern Gujarat, India. In that location, the question is being asked if ecosystem degredation can be reverse by growing organic structures from unruly, invasive plants. In Nagold, Germany, the Plane-Tree-Cube has been installed with plane trees (Platanus acerifolia) and steel and will be unveiled at the horticultural show in 2012. This living structure is designed for an urban context and will part of a townhouse development after the show (Figure 55).

The research in Germany into baubotanik is a multi discipline approach involving architecture, engineering, the humanities and natural sciences. The construction method of using growing plants has been utilized to realize several projects in the last few years. In 2010, two design firms arose from the former Entwicklungsgesellschaft für Baubotanik, founded in 2007. Baubotanik research and practice has been further developed into different distinct profiles, which are documented and elucidated on the websites: www.bureau-baubotanik.de, www.ferdinandludwig.com, and www.baubotanik.org/en. The living willow tower is the PHD project of Ferdinand Ludwig, advised by Professor Gerd de Bruyn (Igma, University of Stuttgart) and Professor Thomas Speck (Plant Biomechanics Group Freiburg, University of Freiburg). The building was designed and build in collaboration with the sculptor Cornelius Hackenbracht (Neue Kunst am Ried, Wald-Ruhestetten) and is supported by the Deutsche Bundesstiftung Umwelt, several companies, engineering offices and further sponsors. Professor Gerd de Bruyn, director of the research expects that scientific progress in using live plants in architectural construction will follow from the success of baubotanik. The concept behind this research is to show the viability of load bearing architectural living buildings as well as provide a model for living structures that will add so many health benefits to the ecology and aesthetics in cities.
These structures have been featured in numerous publications and books. There are courses and seminars available in Germany. Packages of The Light Tree and the Pavilion are already available commercially for sale. My Green City: Back to Nature with Attitude and Style by Klanten, Ehmann and Bolhofer (2011) shows some of the baubotanik structures as part of demonstrating a countermovement to bringing nature back to cities. Klanten aims to show that living plants in cities is fashionable and stylish, though. The cooling, aesthetic, sensual and meditative environments created by these structures provide a contrast to dense urban environments. Attitude is all important is securing the success of living structures in the urban environment.

As stated on one of the web sites covering this project:

"'Baubotanik' is a method of construction that utilizes living plants as the load bearing systems in architectural structures. Baubotanik takes advantage of the ‘constructive intelligence’ of plants. At the same time the concept exposes architects and practitioners to the bio-dynamics and uncontrollability of the natural growth process. By attempting to control the growth process of the plants, the loss of control becomes inevitable. Through the exploration of this conflict, a form of architecture emerges that is characterized by accidental processes, hope and risk." (www.bureau-baubotanik.de).

This quote is very important as it gets to the heart of the issue, which is using the constructive intelligence of plants and understanding the uncontrollability of the natural growth. Risk and hope will now enter into the equation. The success of this new form of architecture will involve a new societal attitude and one that it can be argued is necessary for sustainable ecological architecture. Baubotanik structures challenge the cultural norms of architectural strength materials. The seeming precarious architecture gives rise to a truly permanent architecture of infinite duration. Living structures are never finished as such. They become stronger over time and the cultural plus environmental growing conditions have to be monitored as they are being established. Baubotanik is robust architecture.

**Future Forms and Locations of Living Structures in Landscape Architecture**

As shown above, living structures are likely to become more popular with landscape architects and other designers in the future. The fedge method allows a structural form to be built completely and instantly, at one time. The fedge and poling method can give a much larger range of shape and height options using the metal core. There can be some immediate greening up to the height of the rooted willow rods and then the rest of the structure will be greened over a number of years by attaching the new growth to the covered core of the shape. In Baubontanik (a type of poling method), it has been observed that pre-built trays of willow modules can be grown and then brought to a multi-storey structure. In this way, completion of the structure and achievement of multi-stories is attained sooner. The Germans provide an advanced model in the united relationship of engineering and architecture for this new biological architecture. It is likely that it will take a while to be applied in the United States but nonetheless provides a sterling example of new thinking. In arborsculpture, a longer time frame is involved as there is the necessary time for the whole trees to grow and be grafted at keys points to attain the desired shape. From ten to eighty years has been quoted for complete grafting. This makes this method less pertinent but as seen with the Patient Gardener development in Italy, they were not inhibited by the 80 year projected lifespan to maturity. Therefore, the fedge and fedge plus poling methods have the greatest application in the immediate future in landscape architecture in the United States.

All of these methods and, particularly, arborsculpture can be applied by artists to the experimentation of form, both living and alive. The artists discussed above will probably continue with these journeys. It is also expected that more people will join their ranks as the desire to be in touch with nature by working with living material increases. Living expressions will increase in urban areas. Living walls using the fedge method are far less costly than present green walls and living fences can be freestanding. The continuing use of thick double willow fences (filled
With soil) as sound barriers will be probably become more popular as the greening movement continues and where freeways slice through cities. Living willow sound barriers reduce noise and capture some of the pollution generated by passing cars (Labrecque et al, 2005).

With the growth of garden based learning in schools, willow structures will be increasingly popular for shade, definition, form and function in school yards. Parks are also becoming more interested in having structures for interest and play. Sharon Danks (2002) defines four ways that living structures can be used in school grounds and parks as props for informal play activities and to facilitate formal outdoor academic instruction. Most of these forms involve the fedge method. The first method involves space definition with living fences to define and separate different use areas, such as activities for different age groups and different types of activities, including boundaries of properties. Danks defines a second use in living willow mazes and tunnels for play. These structures increase children’s enjoyment in play and give them access to living green nature. Children love running down living tunnels and through mazes. A third use for living structures is as enclosed spaces in the form of living willow domes and teepees. These enclosed structures provide a private retreat where children will “play house” or relax away from a busy school yard. Domes are also used as meeting places for outdoor lessons and for small group projects. The fourth use of structures is as entry markers and open meeting places in the form of archways, pergolas and sculptural forms. Pergolas are likely to use the poling method within the height of the available willow rods. These structures mark entrances, act as focal points, meeting places and a site for lessons. In addition, the living willow can be woven into sculptural form such as animals. Danks sees great potential for landscape architects to be involved in the design of these more complex and thematic based living willow installations. The author has built many structures in schoolyards where the faculty and students participate in the design and construction which adds to the experience of everyone on some many levels.

Public and private gardens as well as sculpture parks and community centers are increasingly interested in the location of living structures in their grounds. Living outdoor rooms are very popular in private gardens providing a leafy bower in which to relax. The author is usually asked to incorporate openings in the form of doors and windows into the structures. These openings are maintained through pruning. Lighting is often incorporated giving a magical atmosphere at night. These structures can be a large dome using the fedge method or can be made with poling or a combination of the two methods. In the latter, the fedge provides green walls and roof to the structure as opposed to open sides in a pure poling structure. Restrictions on building on large city rooftops are also creating the need for living willow pergolas which meet building code and ordinances as opposed to conventional materials.

In the Land Art movement, living installations are one facet and sculpture parks are including living pieces. The author has a commission to build a living willow installation at Sculpturefest in Woodstock, Vermont in 2012. This installation will involve large rock and a canal. Community centers are interested in structures for contemplation and focal interest. All public installations of living structures offer the opportunity for community members to participate in the design, installation and maintenance. The community then becomes deeply vested in the success and maintenance of the structures.

Much potential exists for living structures at the corporate level. Many large corporations invest a certain percentage of their profits into art on their campuses. Living structures in the form of functional structures or art sculpture could become popular. It also can be argued that for a new awareness and application of living structures to occur, making inroads at the corporate level may well be the road to successful wider applications. If corporations adopt living structures, then public awareness will increase regarding their potential uses. Such translations of form could include pavilions for public parks and office parks; golf cart storage and fairway resting stations on golf courses; and possibly bus stop shelters, particularly park-and-ride bus stop shelters in strip mall parking lots. Golf cart structure could use fedges on the long sides in order to give green enclosure, and poling techniques could be used on all structures. An impermeable roof can be provided by a flexible sheathing material attached to the poling structure.
At the public level of community infrastructure, present forms of covered shelter can easily be translated into living structures. Bus shelters and bicycle rack shelters with a metal core would not be difficult to construct. No one has yet developed a living impermeable roof. Marcel Kalberer uses tenting inside his living structures, for example the church cathedral in Rostock, Germany. His structures which involve a community stage often have a metal frame over the stage on which a non-live waterproof membrane can be stretched. Architectural and engineering research is moving in the direction of bio inspired adaptive architecture (Mostafavi, 2001, 308-309, 560–567). Chuck Hoberan, winner of the 2009 Wyss Prize for Bioinspired Adaptive Architecture demonstrated a first step in this direction with his “Adaptive Fritting” installation at the Harvard Graduate School of Design. The fritting design involves a modulation of the opacity of glass. This adaptation hence controls light transmission and thermal gain. The goal is to create buildings that are able to sense environmental cues and be able to adapt their shape and functions to achieve maximize sustainability. Research into impermeable roofs for living structures may well involve the use of inclusions.

Conclusions

The field of living willow structures is changing as the world changes. The discussion at the beginning of this paper addressed some of these forces of change in the natural and human modes. All of this discussion points to the need for and benefit provided by incorporating nature into urban environments and to design and create structures and habitats that are useful in the pursuit of ecological sustainability. Humanity is moving from the Technology Age to the Innovation Age. As shown, there has been a history of visionary applications to living structures. The work of Mitchell Joachim and his group as they start to build and actualize the Fab Tree Hab and Willow Balls will put this work in immediate practical application. The Living Machine system that he is using was designed by John Todd at the New Alchemy Institute in the 1970's and is used by permaculturists the world over. It often takes time for new ideas to be actually implemented and actualized. Konstantin Kirsch continues the building of living homes.

Living structures provide many solutions to sustainability issues. These buildings take up the carbon dioxide from breathing and provide oxygen in a symbiotic relationship. Taking the work of Bautotanik, Joachim and Kirsch together, there is the notion of healthy living provided by living in and cooperation with nature. This close relationship provides peace, relaxation and a slower lifestyle. Joachim’s Fab Tree Hab provides a model for a complete recycled system of food and waste. Both Kirsch and The Patient Gardener demonstrate examples of growing trees that provide food as well as structure. Living structures become stronger over time. The living willow structure built in Riverside Park on the banks of the Susquehanna River in Tunkhannock, Pennsylvania by the author in 2004 endured a 200 year flood level the winter after it was built and while roads, playground equipment were torn up, the structure remained unscathed. The resiliency of willow cannot be overemphasised.

These structures require a new philosophy towards time and a caring relationship with nature. A paradigm shift is necessary for the success of future structures. Human beings must see themselves as being active and willing participants who have an ongoing relationship with the application, use, maintenance and stewardship of these structures. Patience will be necessary to see fruition. It will be imperative to create human support systems. As in the case of the living root bridges, there is an understanding that the generations that follow are taught their role in continuing the work of maintenance and development. This trait builds community which is so necessary for human connection and successful community building. All living structures, built by all methods, require caring and maintenance. One can go as far to suggest that these living building become ‘pets’ with the necessary care and concern given to domesticated animals. The maintenance is not arduous but consistent and thoughtful. This type of maintenance also nurtures ourselves and our relationships with the living earth. The maintenance and care of living structures bring people in intimate contact with nature. Ferdinand Ludwig of Baubontanik discusses how trees become teachers of place with their nurturing presence and engender qualities of patience and peace.
Living structures are most easily applied as one storey, non-load bearing spatial forms. In order to make the transition of living structures into society, pre-packaged kits of rods and instructions could easily be made available immediately for homeowners, schools and community groups.

Such examples might be for the building of gazebos, outdoor living rooms, arbors and domes. Later, kits of living car ports, sheds and sun porches could be offered. At the corporate level, larger structures can be applied to pavilions, golf cart shelters, bus and bicycle shelters. There will need to be some research into the inclusion of impermeable roof materials but in the meantime, a waterproof roof of some flexible, translucent material applied to a poling or metal structure would be satisfactory. Publicity, on all fronts, will be important in marketing these kit forms. As more structures are built and viewed, more interest will develop to use these structures for the solution of issues discussed earlier and these structures will then become integrated into society.

Willow plants can also be introduced beyond the notion of ‘structures’. We have seen willow used in different art form. In this context, willow ‘space’ can be very relevant where the form, texture and nature of the plant are explored for human enjoyment. Willow can then become a membrane rather than a structure. Due to the large natural growing range of willow, there is great potential for cultural adaptation and regional character to be expressed in living willow applications.

It has yet to be determined the cost of these structures in relation to conventional building. The recreational park, schoolyard, art and community structures are inexpensive and provide instant three dimensional green space. Kirsch states that his roomed structures have few costs as the willow itself is free. The inclusions of the basic servicing infrastructure will add costs but can be minimized for a frugal life style. The cost of the Joachim Fab Tree Hab will be revealed as they are constructed. Joachim has already developed a Business Plan (www.terreform.org) for their construction. A new way of thinking with regard the normal cost benefit analysis will be necessary when the true costs of environmental health are factored into these structures versus conventional building practices.

We are now at a time in human history on earth when there is great need to move forward as a species in a truly sustainable relationship with nature. Living structures involve a true cooperation with nature. Living structures become stronger over time. Living structures can be a part of the solution. Christopher (2006, 160), referring to the work of the author, states:

“But I am a gardener, and I understand the revolutionary quality of her living architecture. At its heart, every garden is a confrontation, a push and shove between the manmade and the natural. That, I believe is the point of gardening: by teasing wild elements, plants, rocks and soil into a human friendly space, we make a truce with the natural world that man moved out of so long ago. Living willow architecture, though is more than a ceasefire. It’s a reunification, a point in which plant and gardener truly partner. And that, as Bonnie Gale observed, truly is ‘shocking’.”
References


Hunter, Ian. [www.littoral.org.uk](http://www.littoral.org.uk)

Joachim, Mitchell. [www.archinode.com](http://www.archinode.com), [www.terreform.org](http://www.terreform.org)


Kalberer. Marcel. [www.sanftestrukturen.de](http://www.sanftestrukturen.de)


Kirsch, Konstantin. [www.treedome.com](http://www.treedome.com)


Living Root Bridges. [rootbridges.blogspot.com/](http://rootbridges.blogspot.com/)


Reames, Richard, [www.arborsmith.com](http://www.arborsmith.com)


Schuiten, Luc. [vegetalcity.net](http://vegetalcity.net)


SUNY-ESF (State University of New York, College of Environmental Science and Forestry). [www.esf.edu/willow](http://www.esf.edu/willow)


Visiondivision. [www.visiondivision.com/](http://www.visiondivision.com/)


Biographical Sketch

Bonnie Gale has been a professional traditional willow basketmaker and willow artist for the past twenty eight years. A Kennedy Scholar with degrees from the University of Manchester and Massachusetts Institute of Technology, she has trained with professional European willow basketmakers. She is proprietor of "English Basketry Willows" (a small business selling imported European basketry willows, willow basketry books and tools) and founder of the "American Willow Growers Network" promoting the growing and the exploration of the uses of willow. She teaches traditional willow basketry across the United States at major conventions and guilds. She writes extensively on traditional willow basketry and willow growing and her articles have appeared in Early American Life magazine, Basket Bits, Basketry Express and Fiber Arts publications. Her work has been shown in major basketry exhibitions and she is the recipient of numerous awards. In 1999, she was awarded an Artist's Fellowship from the New York Foundation for the Arts. She was asked by Plimoth Plantation to make the large willow baskets featured on the film set in the PBS WGBH Boston television series “Colonial House” first aired in May 2004. In 2004, she started building living willow installations and in March 2006, her installations were featured in “House and Garden” magazine and her work was also shown in the Fall/Winter 2006 issue of “Vogue Living” magazine. In September 2006, she was commissioned by the Mount Vernon Estate to make a basket to specifically hold Martha Washington’s love letters. In 2007, she was awarded an Artists & Communities grant from the Mid Atlantic Arts Foundation to engage in a large scale community oriented living willow installation at the Lake Erie Arboretum at Frontier Park in Erie, Pennsylvania. In 2009, her work was featured in the PBS "Cultivating Life" series and in 2010, she appeared on the Martha Stewart Show.