

# **BioSphere2**

near Tucson, Arizona

January 2014

THE UNIVERSITY OF ARIZONA



## B2 Institute

### B2 Institute Mission

B2 Institute is addressing scientific Grand Challenges whose solutions require the combined expertise of people from a broad range of scientific fields with diverse interdisciplinary talents. The Institute provides a non-traditional structure that facilitates interaction. As part of its mission, the B2 Institute is helping the state of Arizona address the emerging challenges of extreme growth and fragile environment. B2 Institute is building upon The University of Arizona's reputation as a trailblazer in interdisciplinary research. The goal is to create both extended programs and shorter, broadly attended conferences. Plans are underway to create a summer or winter school aimed primarily at graduate students and postdoctoral fellows.

The buildings around you form the "Village", a modern housing facility of 28 furnished three-to-five bedroom casitas that are used by the Institute.



Where science lives.

## biosphere village phenology garden taking the pulse of our planet

**This garden** is part of a nationwide effort to help scientists track impacts of climatic variation and change on the natural world. We are monitoring the timing and occurrence of seasonal events in this garden and reporting the observations to USA-NPN's national database.

**What is phenology?** Phenology is the study of recurring plant and animal life cycle events such as leafing and flowering of plants, emergence of insects, and migration of birds. Many of these events are sensitive to climate change and are simple to observe.

**What is USA-NPN?** The USA National Phenology Network brings together citizen scientists, government agencies, educators, students, and nonprofits to monitor the impacts of climatic variation and change on plants and animals across the U.S. The network harnesses the power of people and the Internet to share information and provide data to researchers.

**How can I get involved?** USA-NPN invites you to volunteer as an observer so that we can better understand environmental trends and adapt to climate change. Your own yard can serve as a phenology garden where you observe plants and report your findings.

Visit [usannpn.org](http://usannpn.org) to participate!



**USA npn**  
National Phenology Network

**Biosphere 2**  
THE UNIVERSITY OF ARIZONA.

**USGS**  
science for a changing world

**THE UNIVERSITY  
OF ARIZONA.**



**Where science lives.**





## soaptree yucca *Yucca elata*

### Did You Know?

Soaptree yucca is a native to southwestern North America. In the past, a soapy substance found in the roots and trunks was used as a substitute for soap and the leaves were used for everything from dental floss to rope, sandals and woven baskets. In times of drought, the plant has been used as an emergency food source for cattle.



### Phenophase Key

Use this key to help you make your observations.

#### FLOWERS

##### Do You See...?

1. Closed buds

One or more buds. Buds are flower buds. They are the undeveloped flowers that will later open. Buds are small and round.

OPEN FLOWERS  
One or more open flowers are visible on the plant. Flowers are considered "open" when the reproductive parts (male stamens or female pistils) are visible between unfaded or open flower parts. Do not include wilted or dried flowers that remain on the plant.

#### FRUITS

##### Do You See...?

1. Fruits

One or more fresh fruits are visible on the plant. For Yucca, when the fruit is a capsule that changes from green to tan, brown or dark brown, and splits open. Do not include empty capsules that have already dropped off all their seeds.

nature's  
notebook

@Biosphere 2

Become a citizen scientist today!  
Datasheets are available at the B2 Visitor's Center  
[usanpn.org](http://usanpn.org)







**Biosphere2 Solar Test Bed**

**Biosphere2**  
The Biosphere 2 Project

the biosphere 2 solar test bed was made possible thanks to the following partners and sponsors:

**SOLON**

**SOLARMAX**

**Firestone**  
SPECIALTY PRODUCTS

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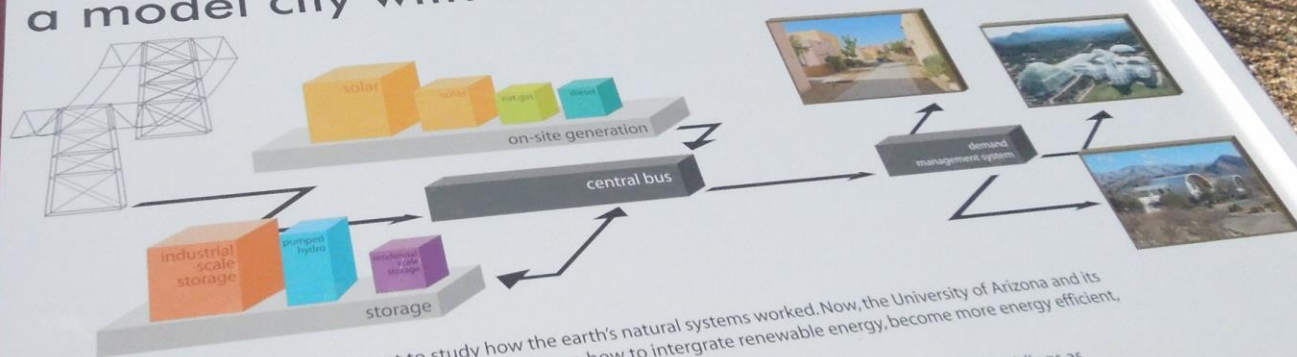








## rethinking the grid a model city with new technology



B2 was built to be a model environment to study how the earth's natural systems worked. Now, the University of Arizona and its industry partners are using B2 as a model city to better learn how to integrate renewable energy, become more energy efficient, and increase the security and reliability of the electric utility grid.

How can B2 be used as a model city? By looking at the casita village as a residential area, the administration buildings as commercial business, and the biosphere as an industrial area, researchers can simulate the energy needs of a city.









Pressure door to enter living spaces





Finite natural resource • Sport • Conservation • Connection •  
Extinction • Hydroelectric power • Isolation • Natural disasters •

How has water affected your life today?

# WATER & LIFE



**Halloween Swamp**  
Cypress Creek National Wildlife Refuge  
Illinois

Swamps are defined as lands of water saturated soil characterized by standing, standing or slow-moving bodies of fresh or salt water. They are characterized by a rich biodiversity that is dominated by flora capable of a surviving long-term flooding and by the presence of a specialized semi-aquatic fauna, including amphibians and reptiles.

Swamps provide a physical buffer against flooding. In spite of their importance, the government regulations on timber harvesting and clearing for agricultural purposes have led to a 75 percent reduction in the swamp acre covered by forested Southern swamps in the United States. Mangrove swamps have not been as adversely affected but many are currently at risk due to incalculable effects for residential development.

Many wetland ecosystems are likely to survive and even flourish only if appropriate measures are implemented in the near future.



**Fun with frozen water**  
Alpine skier  
Semmering, Austria

What's better? Whatever you can do with liquid water you can do with frozen water just as well. We are fortunate to live in an integral period of moderate temperatures and regular precipitation. Climate change may change all of that. As temperatures rise, snow will diminish in its frequency and total. As the snow will turn to gray, imagine your world.

Life is either a daring adventure or nothing!

—Hermann Hesse



**Saharan oasis**  
Africa

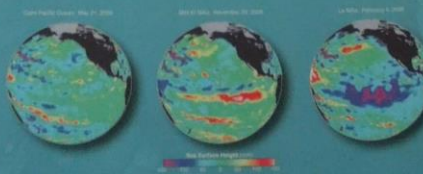
Approximately 1.1 billion people worldwide do not have access to clean water. Population growth, pollution, and climate change will undoubtedly cause an increase in that figure during the 21st century.

By the year 2025, it is predicted that nearly 2.8 billion Africans will be facing water scarcity and another 400 million will live in water-stressed countries.

Source: World Bank, International Water Resources Institute

Art • Destructive power • Soil erosion • Terror













# PHENOLOGY


Can you find three Wilson's Warblers in each of the photos?

Display created by Kathi L. Borgmann  
School of Natural Resources, University of Arizona




Each photo was taken at the same location on May 31<sup>st</sup>, June 2<sup>nd</sup>, June 16<sup>th</sup>, July 2<sup>nd</sup>, and July 11<sup>th</sup>. Notice the dramatic changes in the plants throughout the summer months. The changes in plants you see in these photos such as leaf out, growth, and flowering are called **phenology**. These phenological events are sensitive to climatic variation and change.




Phenology is the study of plant and animal life cycle events and how these events are influenced by seasonal and yearly variations in climate.

Phenology can also affect songbirds. Finding nests in the first two photos was easy and is likely easy for **nest predators** that eat bird eggs. Later during the summer months, nests may become more difficult for nest predators to find because plants cover up the nests. Plants covering a nest can decrease the chance that a nest predator will find the nest and increase the chance that the babies will survive.



Nest predators include animals such as jays, squirrels, crows, and chipmunks that eat eggs or babies in a bird's nest.

Changes in climate can alter patterns of phenology which can in turn impact songbirds and other organisms. The USA National Phenology Network is teaming up with citizens just like you to determine how changes in phenology are affecting plants and animals. Together they are building a nationwide network of people observing important phenological events. To learn more about how you can participate please visit [WWW.ANNPHENO.NET](http://WWW.ANNPHENO.NET) or take a brochure.





# The Effect of Climate Change on Biodiversity I



## Growing Season Changes:

- **Phenology** is the study of periodic plant and animal life cycle events and how these are influenced by variations in climate.
- There is significant lengthening of the growing season in higher latitudes, resulting in changes to the timing of species' growth and reproduction.
- There is an earlier onset of Spring in temperature latitudes by 10-14 days.
- Climate change signature is apparent in the advancement of spring migration phenology of birds and butterflies.
- In regions subject to drought, animal and plant growth rates have decreased.

***Disturbances created from the interaction of drought, pests, disease, and fire are projected to have increasing impacts on forests and their future distributions.***

This poster is adapted from a chapter in the publication: *The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States* published by the U.S. Climate Change Science Program in May 2008.

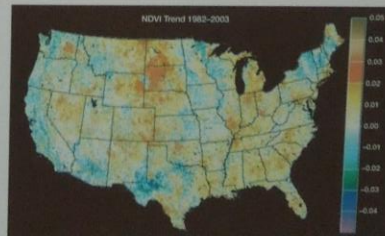
## Pests and Pathogens:

- Evidence that links the spread of pathogens to a warming climate. One example is the chytrid fungus infecting amphibians that is spreading worldwide and wiping out populations.



Photo credit: David Cappaert, MSU, Bugwood.org

- There is evidence that latitudinal shifts in vectors and diseases are occurring under warming temperatures.
- Climate change is expected to facilitate the establishment and spread of exotic invasive species.



Changes in U.S. vegetation observed by satellite between 1982 and 2003.



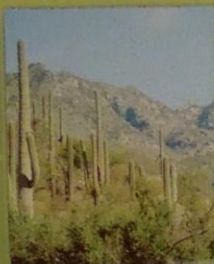
# Forests in the Desert: Riparian Environments



1: Riparian Area



2: Map of the Arizona/Sonora Border



3: Sonoran Desert, Arizona, USA



4: San Pedro River, Arizona, USA



5: Rio San Miguel, Sonora, Mexico

## Forests in the desert?

Deserts are not usually known for their forests. In deserts, riparian areas are the narrow forested strips on either side of a river (see box #1). These are some of the very few areas where large trees exist in the desert regions of southern Arizona, USA and northern Sonora, Mexico (see the map in box #1). Usually when we think of the Sonoran Desert, the first thing that comes to mind is the Saguaro cactus (see box #2). But the San Pedro River that flows north from the state of Sonora in Mexico into Arizona has a healthy riparian area (see box #3) that is protected by United States law. In Sonora, the Rio San Miguel (no means river, in Spanish) also has a heavily vegetated riparian corridor (see box #5).

## Why are riparian areas important?

Humans depend on riparian areas for a wide range of livelihoods, including ranching, agriculture, mining, recreation, and tourism. However, changes in rain patterns and temperature and the growth of cities are changing the environmental conditions upon which these forests depend. As the forested river corridors change, peoples' activities also must change to adapt to these new conditions. My research examines how and why people use riparian corridors along the San Pedro River and the Rio San Miguel and the ways that they adapt their behaviors under changing conditions.

# Biodiversity

## Trees

Due to lack of water, most of the desert is vegetated by cactus and shrubs. But, in riparian areas, the availability of water allows trees to grow. Four species of trees common in riparian areas are: Willow, Mesquite, Cottonwood, and Tamarisk.

Can you match the tree to the leaf?



## Birds

The San Pedro River riparian area is one of the top 10 birding destinations in the world! Riparian areas in are vital habitat for up to 250 bird species. Four species are: Green Kingfisher, Yellow-billed Cuckoo, Scarlet Tanager, and Yellow-breasted Chat.

Can you identify the birds?



# Water Management in Riparian Areas

## Acequias

An acequia is a community-managed canal that is used to move water to farm fields for irrigation. Acequias were brought to the United States and Mexico by Spanish colonists. The word acequia originates from Arabic and means "water conduit."

In the Rio San Miguel watershed, surface water resources, such as rivers and streams, are scarce and the topography of the land is mountainous and extreme.

Before the introduction of wells into the watershed during the last two decades, the only location where irrigated agriculture was possible was in the narrow floodplain.

The long history of building and maintaining acequias as a cooperative, community activity has allowed farmers and ranchers to use the limited surface water to sustain livelihoods based on floodplain agriculture and ranching activities.



Acequia in Cucupé, Sonora



Acequia in Cucupé, Sonora

## Wells

Wells are used around the world to access groundwater (water that is held under the ground in aquifers). Groundwater is used extensively in the San Pedro River watershed for supplying water to irrigate fields. Wells are more recent in the Rio San Miguel watershed. Wells allow farmers and ranchers to irrigate land that is far away from rivers and streams.

However, there are drawbacks to pumping large amounts of groundwater. Pumping more groundwater than can be naturally put back into the ground by rain, causes the groundwater table to fall. As the water table falls, rivers dry up and trees in the riparian areas can not access water and begin to die.



Electric well



Irrigation Water from a Well

## Transition from Surface to Groundwater Use

Historically, surface water from rivers, streams, and springs, was used to irrigate agricultural fields in the San Pedro River and Rio San Miguel watersheds. Due to the low amount of rain and high temperatures experienced in southern Arizona and northern Sonora, irrigation is often necessary to grow crops and other agricultural products.

During the twentieth century, electric pump wells have become popular and widespread throughout southern Arizona and more recently in Sonora, Mexico. Groundwater is an important supply of water in areas that have scarce surface water supplies. The transition from surface water use to groundwater use is important and has cultural and ecological implications. For example, the acequia system may become a historical artifact if groundwater pumping takes over completely. Also, the health of the riparian ecosystems are likely to decline.

# Conservation Projects: Spotlight on the SPRNCA

## San Pedro Riparian National Conservation Area (SPRNCA)

In 1988, the United States Congress designated a 40-mile conservation area, known as the San Pedro Riparian National Conservation Area (SPRNCA). The conservation area was a result of concerns about environmental degradation occurring to the riparian area due to groundwater exploitation and urban development.

The purpose of the SPRNCA is to protect 56,000 acres of key riparian habitat. The area is home to 84 mammal species, 14 fish species, 41 reptile and amphibian species and 100 bird species. The San Pedro River is also a critical flyway for North-South migration of birds, and provides habitat to over 250 migratory bird species.

A number of factors have impacted the success of the SPRNCA, including steady population growth in the city of Sierra Vista, groundwater withdrawal, decreasing rain, and the removal of grazing and most irrigated agriculture from the riparian area.



Map of the Upper San Pedro River basin. The black box around the river in the San Pedro Riparian National Conservation Area.



Wet area has been dried in the San Pedro River



Recreation, dry river bed in the SPRNCA



Mature cottonwood forest in the SPRNCA



Western Green Lizard in the SPRNCA























## Mangroves: From "Walking Trees" to Crippled Forests

### What is a Mangrove Forest?

- ❖ Mangroves are a diverse set of tropical evergreen trees and shrubs that live in warm, muddy, saline water environments
- ❖ Complex root system allows them to adapt to low oxygen, high salinity conditions
- ❖ Global area is 1/2 what it used to be
- ❖ Mangroves have declined 35% in the last decade- this exceeds the rate of loss for tropical rainforests



Image by: Nick Foster

### Mangroves are Vanishing

Mangroves are cleared for shrimp farming and coastal development for housing and industry. Rising sea levels may overcome mangrove forests



Image by: Nick Foster



Image by: Nick Foster



Image by: Nick Foster

### What are some solutions?

Habitat Protection & Restoration  
Establishment of Mangrove Plantations



Policy Standards for Aquaculture Placement  
& Water Pollution Minimization



Preservation of Coastlines

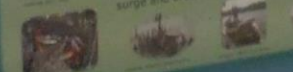


### Why should we care about them?

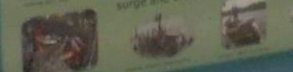
- ❖ Carbon storage serves to buffer climate change
- ❖ Complex root system protects coastline from storms and erosion
- ❖ Provide habitat for a diverse set of species, some unique to mangrove ecosystems only
- ❖ Source of seafood, medicines, and timber
- ❖ Breeding and nursery grounds for many species of fish, oysters, crabs and shrimp.

### Mangrove Clearing Destroys Habitat

Many animals are suffering from habitat loss, including fish, birds, and marine and terrestrial vertebrates and invertebrates



Coastal people are no longer protected from storm surge and erosion if mangrove forests are cleared



For more information on mangrove forests from the Smithsonian Institution's National Center for Conservation and Management of Wetlands, visit our website at [www.nccmw.org](http://www.nccmw.org)



Desert area



















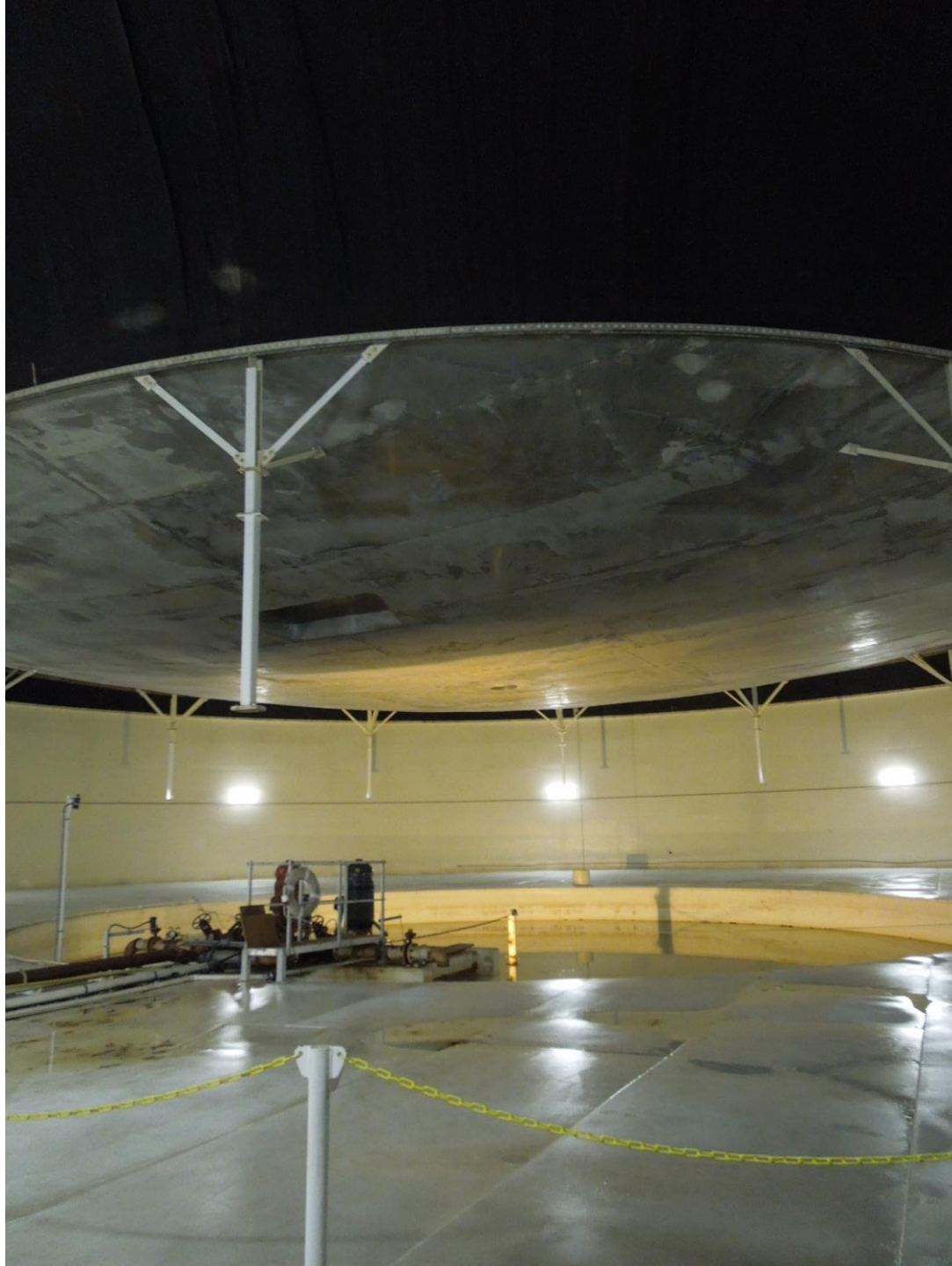














Inside the air bubble





















## Gathering water in the desert

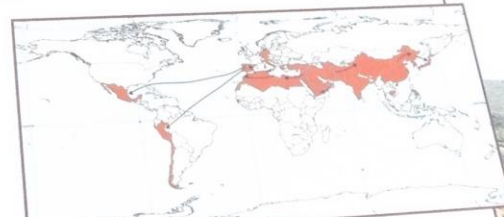
### What is a Falaj?

A falaj uses ancient technology to tap groundwater that originates in the mountains and bring it to a village and its agricultural fields. The technology originated in the Middle East over 2,500 years ago and spread west across North Africa and into southern Europe. In the Middle East, it is known as a qanat in Iran, and a khattarra in North Africa. From Spain, it spread to the rest of the world. The technology also spread east, eventually reaching Japan.

Constructing a falaj was a community effort, and maintaining and administering one involves the entire village; thus, falaj systems are as much social as they are physical systems.

Falaj is derived from an ancient Semitic root which means "to divide," hence the water shares of a falaj are divided among the community. Shares are initially distributed when falaj construction is complete by a committee of experienced farmers, based on falaj characteristics, and each owner's hard work and contribution in constructing the falaj. When the owner dies, land and water shares are distributed among his family.

Some water shares are allocated to the community. These are auctioned out, with the income used to maintain the falaj. Other community shares are used to pay for the money for









Food-growing pavilion

Air pressure bubble

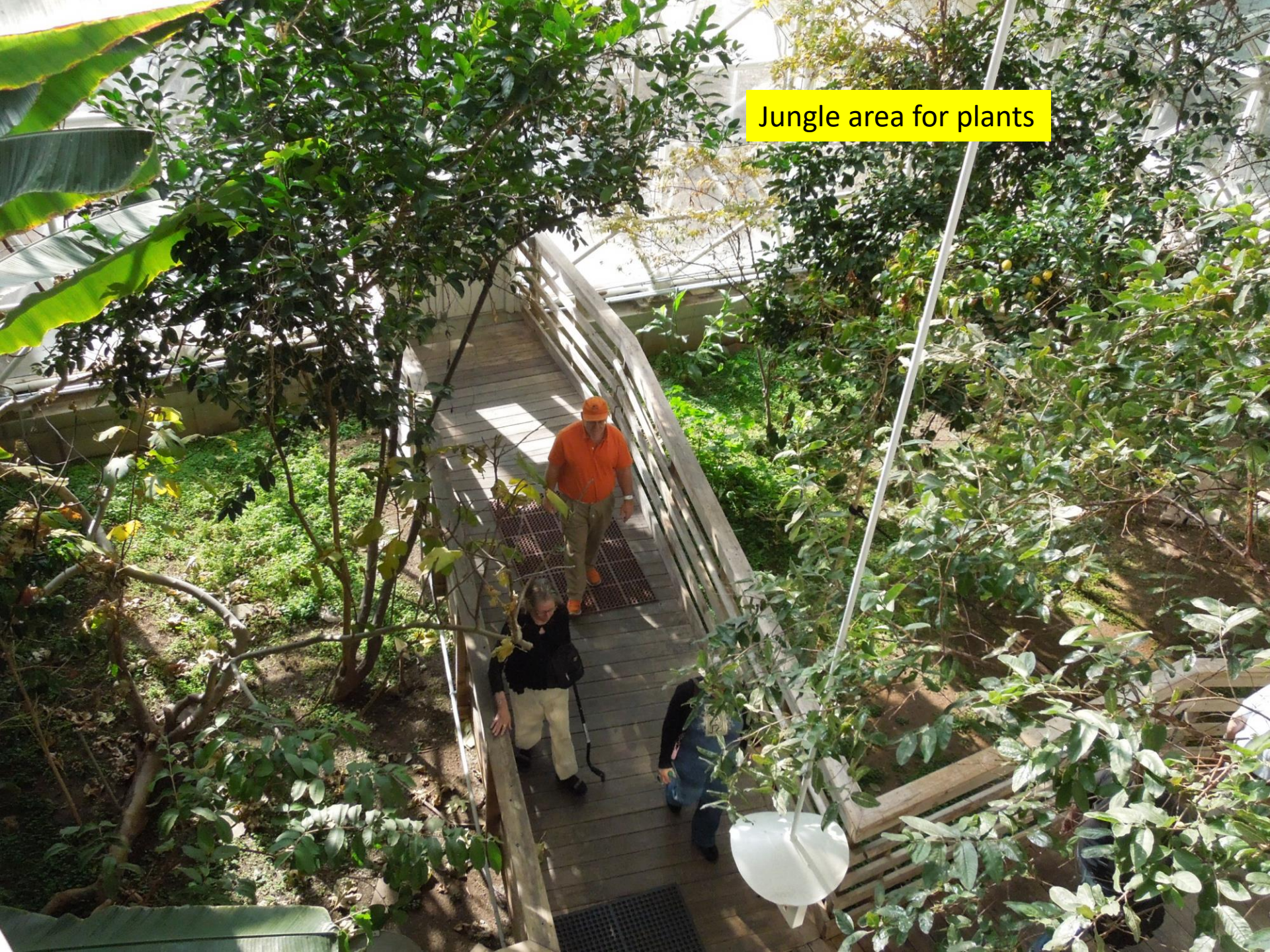








Jungle area for plants





Meeting area for participants













## Service area for Biosphere2

