Water and Energy in Co-ops: Practical Permaculture

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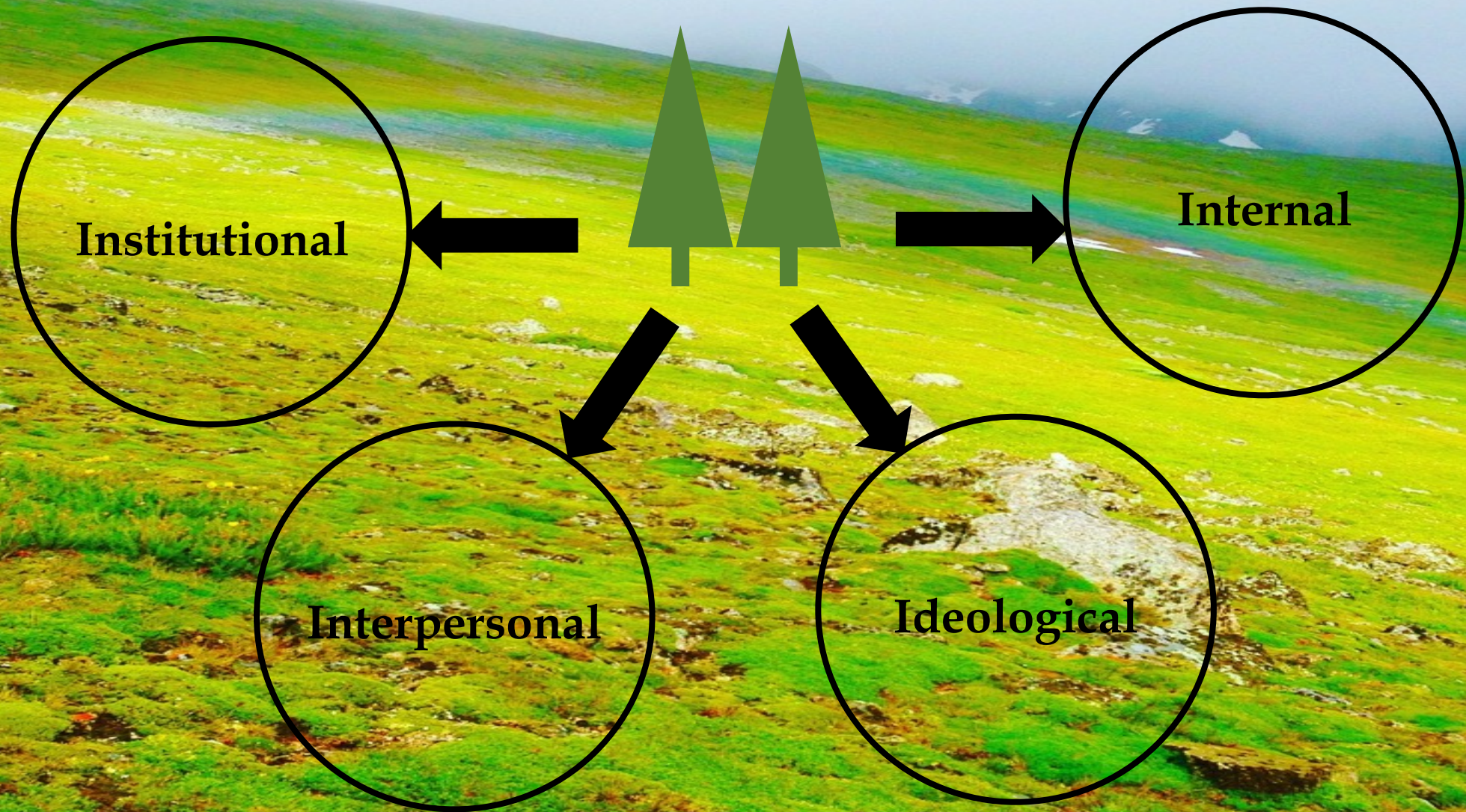
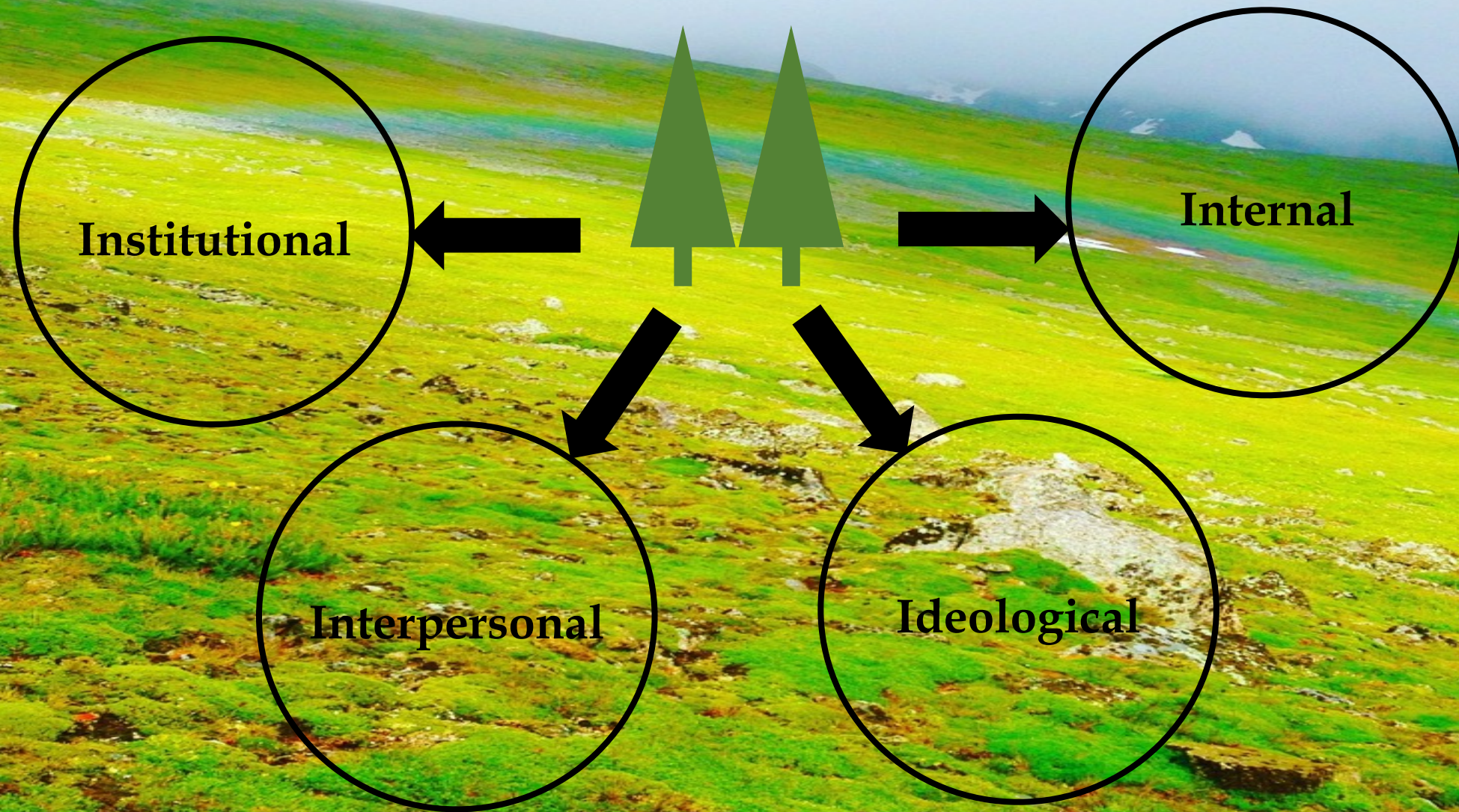### M.S. Civil Engineering

B.S. Physics

Overview

- Ideologies and motivation (5 minutes)
- Taking advantage of the physics of heat and solar geometry (20 minutes)
- Energy and water projects (15 minutes)
- Community project-share (15 minutes)
- Patterns (20 minutes)
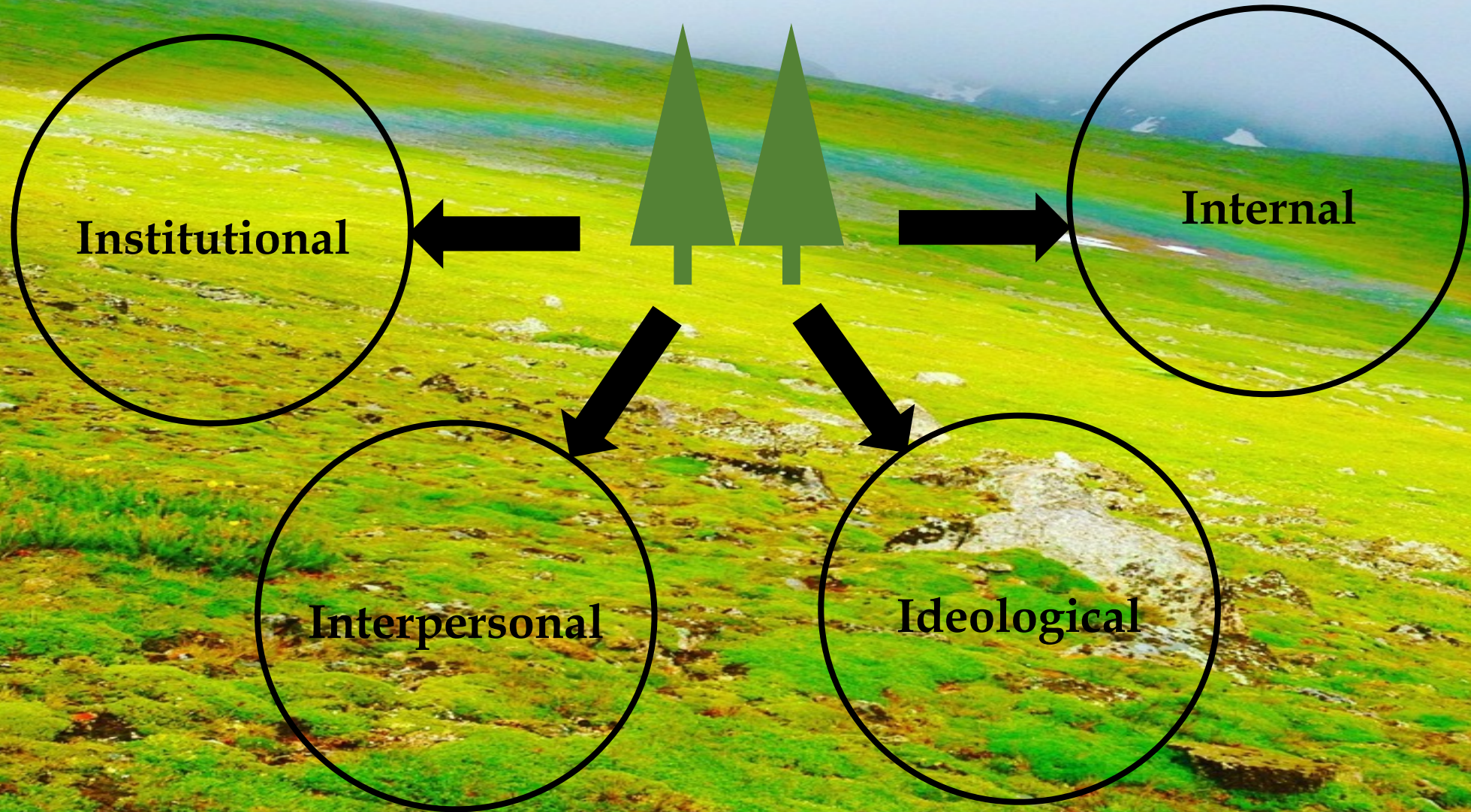- Pattern Activity (15 minutes)

Four I's of Oppression => Activism

What am I suggesting?

- Playful, creative, and silly involvement with the systems that support our bodies
- Restructuring our attitudes towards time and energy, eliminate divide between:
  - Work and leisure
  - Nature and home
- Radical investment in the present and our surroundings
- Leading by example

Observe and interact

Use and value renewable resources and services

Use small and slow solutions

Use and value diversity

Use edges

Mechanisms of Heat Transfer

• • Radiative:

   • Ultraviolet "shortwave" solar radiation:

$$q_{short} \sim \cos(\theta_{zenith}) \qquad \sim 700 \ W \ m^{-2}$$

   • Infrared "longwave" thermal radiation:

$$q_{long} \sim T^4 \qquad \sim 350 \ W \ m^{-2}$$

• Conductive: (diffusion)

$$q_{cond} \sim -\nabla T \qquad \sim 50 \ W \ m^{-2}$$

• Advective:

$$q_{ad} \sim v_{air}\Delta T \qquad \sim 1000 \ W \ m^{-2}!$$

• Convective $\approx$ Advective + Conductive

What to do with this knowledge?

- It has been suggested that humans prefer to be heated *radiatively* vs. *convectively*. Think:
  - Brisk sunny day
  - Chilly night next to a fire
  - Swimming on a sunny day

Cooling

- • Keep doors and windows shut!
- Design your home to reflect short- and longwave radiation: bright surfaces
- Minimize thermal gradients: ($q_{ad} \sim v_{air}\Delta T, q_{cond} \sim - \nabla T$)
  - Keep your air conditioning as close to ambient temperatures as folks are comfortable with
  - Build into the earth (which will be much cooler than the air in the summer)
- Use dense walls with low thermal conductivity - "thermal mass"

Heating

- • Keep doors and windows shut!
- Design your home to absorb short- and longwave radiation: dark surfaces
- Minimize thermal gradients: $(q_{ad} \sim v_{air}\Delta T, q_{cond} \sim -\nabla T)$
  - Keep your heating as close to ambient temperatures as folks are comfortable with
  - Build into the earth (which will be much warmer than the air in the winter)
- Use dense walls with low thermal conductivity - "thermal mass"

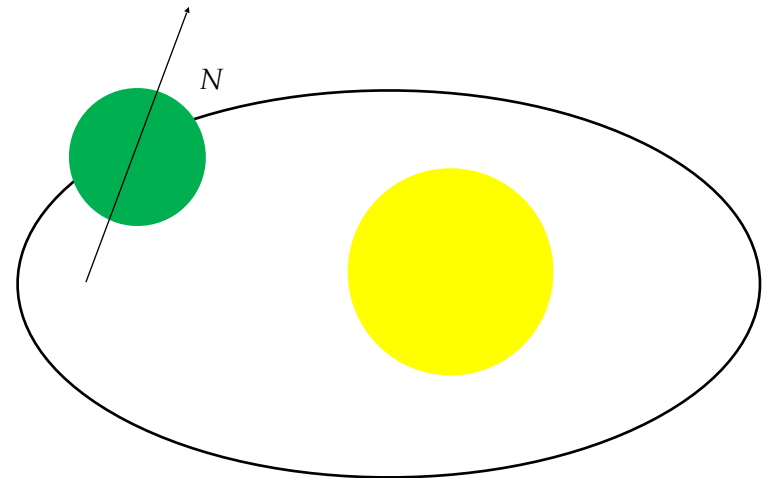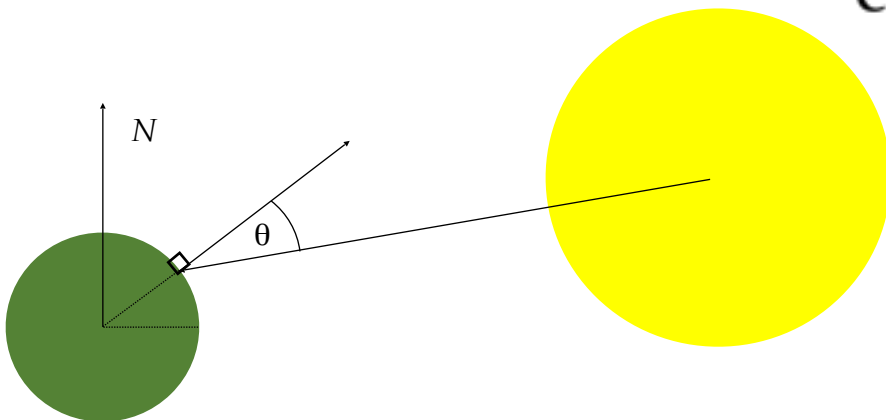# Taking Advantage of Solar Geometry
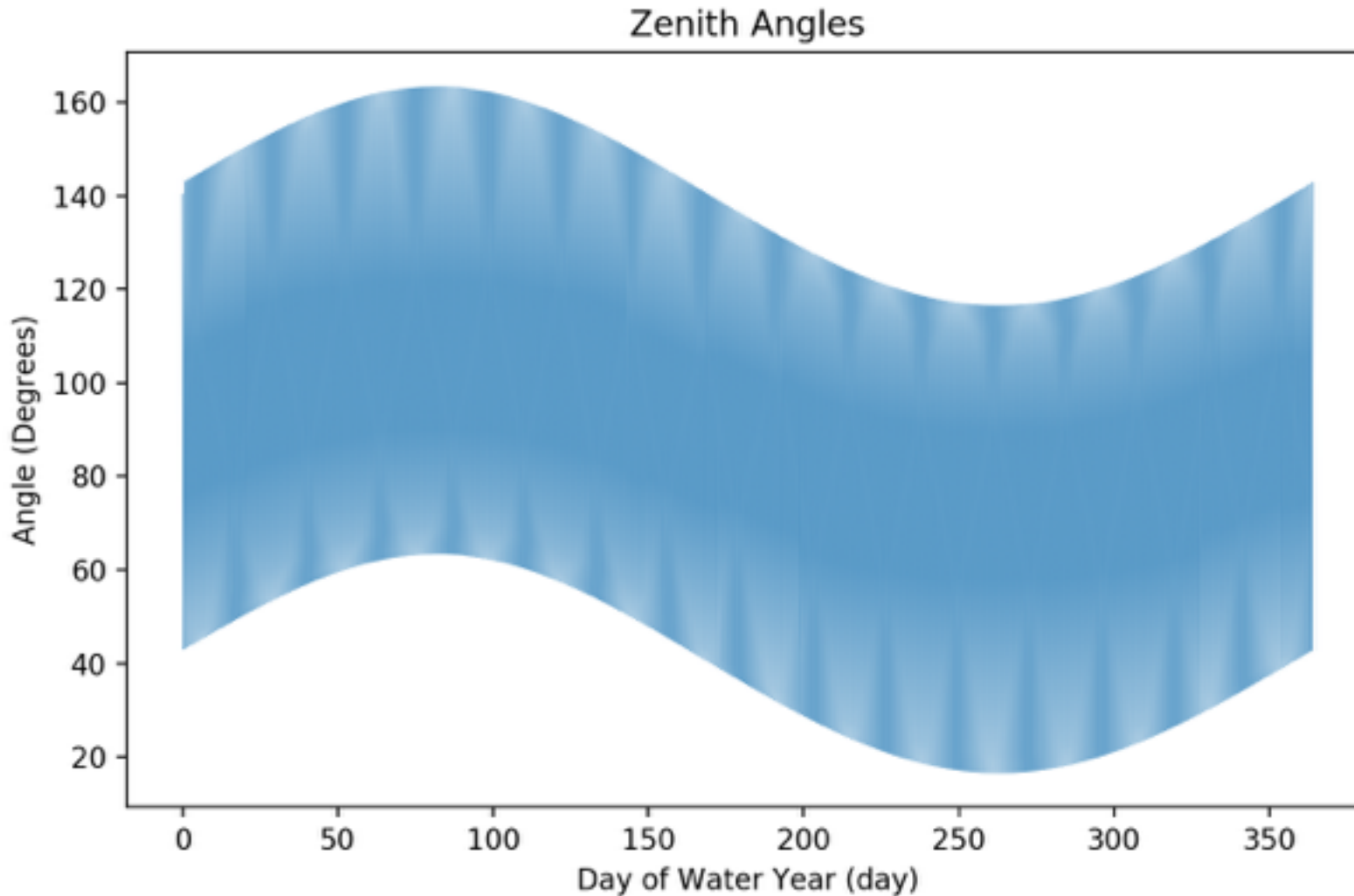
Incoming Shortwave Radiation:

• • Incident "extraterrestrial" radiation flux q:

$$q = I_{sc} E_0 \cos(\theta)$$

I_{sc} is the solar constant ($4921\ kJ\ hr^{-1}\ m^{-2}$) and E_0 is an eccentricity correction.

Zenith Angle θ

$$\cos(\theta) =$$

$$\sin(\Lambda)\sin(\delta) + \cos(\Lambda)\cos(\delta)\cos(\omega t)$$
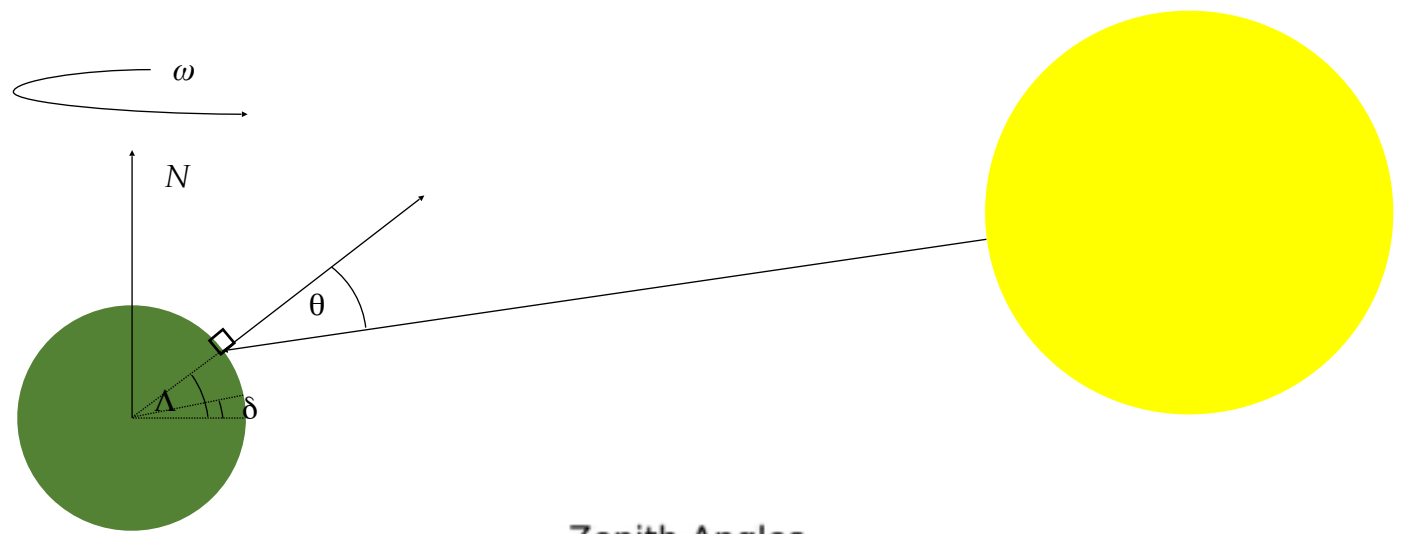
- Λ is latitude, δ is the sun's declination (latitude at which sun is overhead at noon), t is hours before (-) or after (+) noon, and ω is the angular velocity of Earth's rotation $(2\pi\ day^{-1})$.

Maximum sun = minimum zenith angle

Zenith Angles
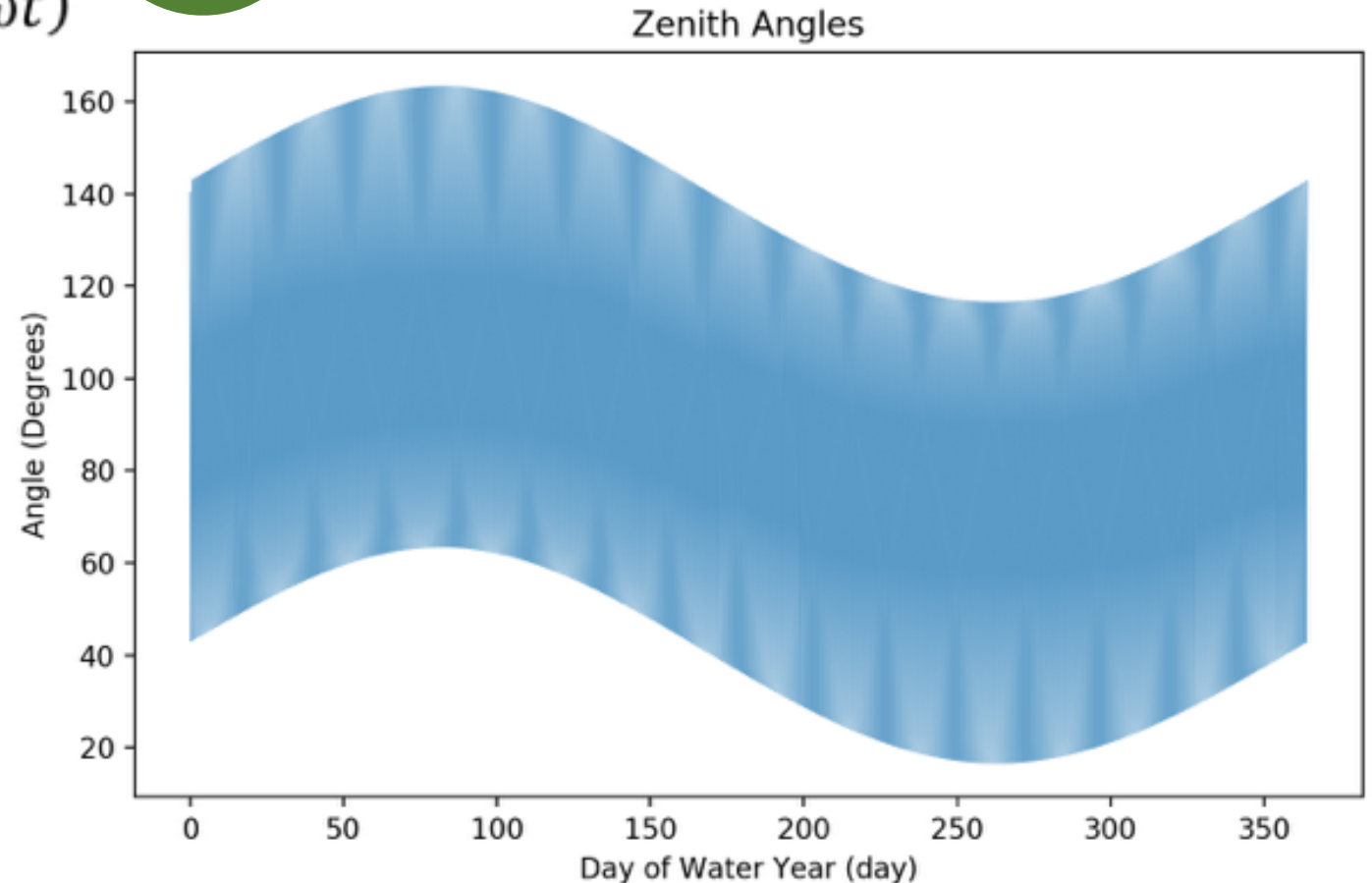
Inclined Plane

- Slope angle (β) and aspect (α):
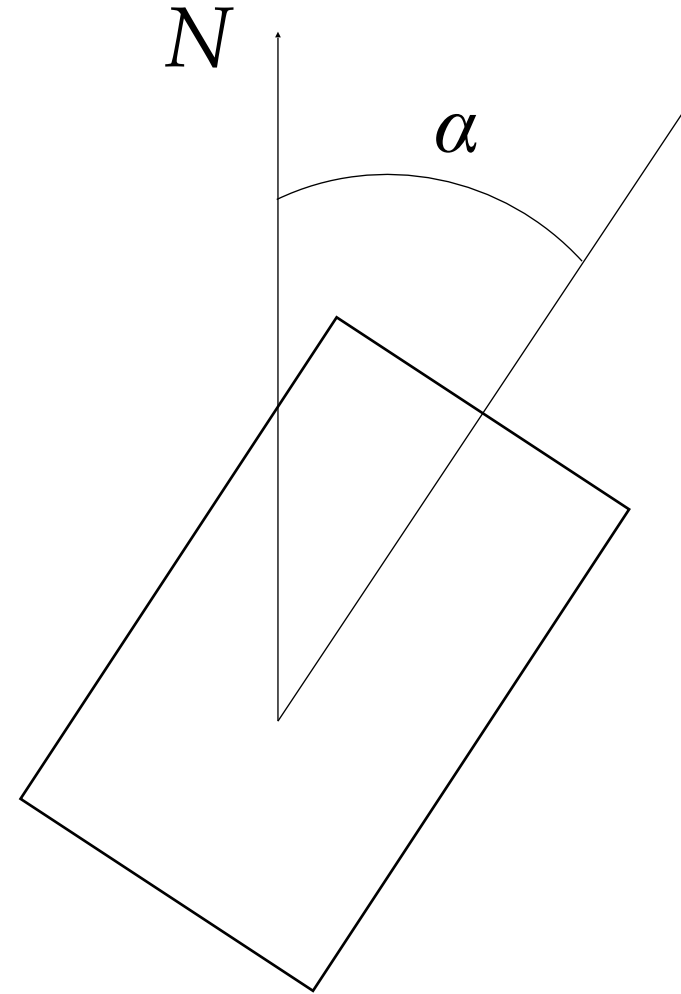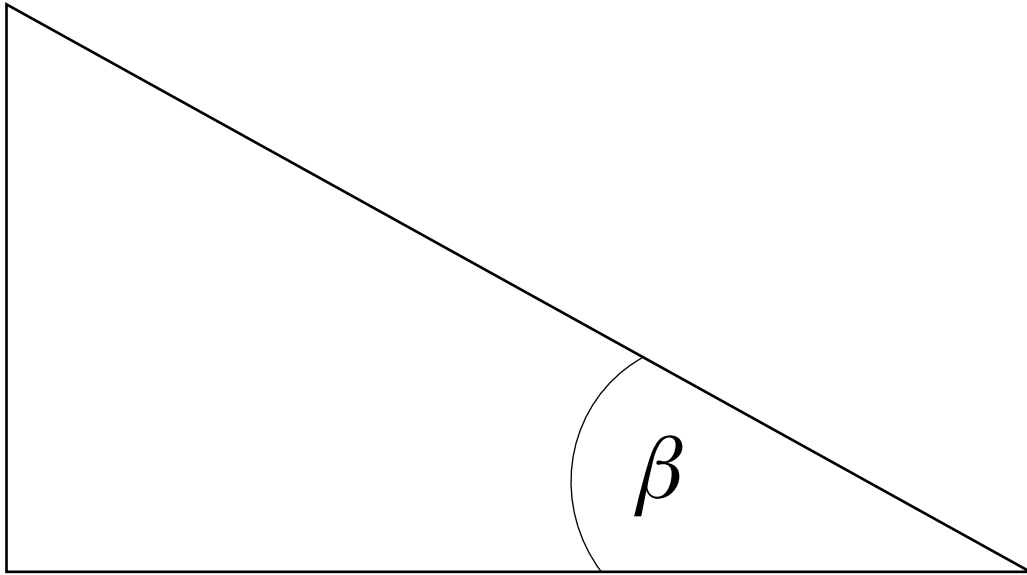
Equivalent Slope (Lee, 1964)

• • A change in latitude corresponds to a shift in *amplitude* while a change in longitude corresponds to a shift in *phase:*

$$K_{et} = I_{sc}E_0[\boldsymbol{cos}(\boldsymbol{\Lambda_{eq}})\cos(\delta)\cos(\Lambda)\cos(\omega t + \boldsymbol{\Omega_{eq}}) + \sin(\delta)\sin(\boldsymbol{\Lambda_{eq}})]$$

$$\Omega_{eq} = \Omega + \tan^{-1}[\frac{\sin(\beta)\sin(\alpha)}{\cos(\beta)\cos(\Lambda) - \sin(\beta)\sin(\Lambda)\cos(\alpha)}]$$

$$\Lambda_{eq} = \sin^{-1}[\sin(\beta)\cos(\alpha)\cos(\Lambda) + \cos(\beta)\sin(\Lambda)]$$

The Tool

- Written in Python 2.7

- Web interface: (Thank you, Ezra Hutcher!!!) http://science.hyperspaceweb.net/solar_angle_calculator/

- Takes inputs of:

  - Slope of your surface (flat=0°)

  - Aspect of your surface (clockwise from north)

  - Latitude of your surface

- Calculates optimal solar panel angle for each day of the year

How to find slope, aspect, latitude

- • Slope: Pythagoras

$$\theta = \tan^{-1}\frac{b}{a}$$
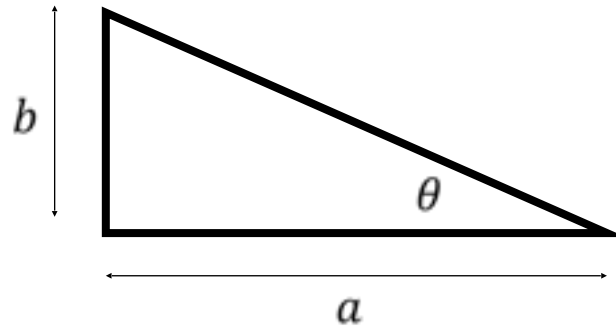
- • Aspect:
  - North-facing: 0°
  - East-facing: 90°
  - South-facing: 180°
  - West-facing: 270°
- • Latitude: Google maps!

How to use the tool

- Select how many times you will adjust your panel:
  - Never: take the average of all angles
  - Twice per year:
    - Switch on the spring/fall equinoxes
    - Average the angles in between equinoxes
  - 4x per year:
    - Switch on the spring/fall equinoxes and on summer/winter solstices
    - Average the angles in between equinoxes and solstices

Other tools:

- To estimate power: http://pvwatts.nrel.gov/pvwatts.php

- Live from Chrysalis: https://enlighten.enphaseenergy.com/pv/public_systems/J3Sr722/overview

Back to Basics

Cold Frames

Water Projects

Effective Rain Barrel Instructions

Tools needed:

- drill
- jigsaw
- hacksaw
- 1 inch paddle bit
- 1 3/16 inch paddle bit
- file or sheet rock knife
- safety glasses

Other items needed:

- silicone caulk or clear epoxy
- 2 feet of 1 inch PVC
- 90 degree PVC elbow
- screen
- 8 small screws
- black marker
- ¾ inch spigot

1. Decide where you are going to place the rain barrel and mark where the spigot, overflow and gutter inlet need to be.

2. Cut the gutter inlet by first drilling a starter hole (drill in the piece that will be discarded) then use the jigsaw to cut out the inlet.

Tip: Use the sheet rock knife to remove all plastic burs, leaving a clean surface. It is especially important for the spigot hole because the shavings can get in the epoxy and leave room for a leak.

3. Use the 1inch paddle bit to drill a hole 2-3 inches up from the bottom of the barrel for the spigot.

   - Tip: The purpose is to drill the spigot hole close to the bottom allowing access to as much water as possible while leaving enough room to install the spigot and attach a hose.

4. Use the 1 3/16inch paddle but to drill the hole for the overflow.

5. Install the 90 degree elbow for the overflow

Attach the 2 foot piece of PVC into the 90 degree elbow (it is not necessary to glue these pieces together)

6. Prepare enough 2 part epoxy to liberally cover the threads of the spigot and still have enough left over to leave a bead around the outside of the spigot.
   - Tip: It helps to let the epoxy start to thicken before installing the spigot so that it doesn't run but don't let set too long because it hardens quickly.

7. Lay the barrel on its side with the spigot hole facing straight up. Cover the threads of the spigot with the epoxy and install it until it horizontal and snug but do not over tighten. Leave it laying on its side for 15min to dry.
   - Tip: Install the spigot horizontally unless you plan on elevating the barrel otherwise you won't have enough room to attach a hose.

8. Cut the screen big enough to completely cover the inlet hole then use the screws to secure it.

9. Finished.
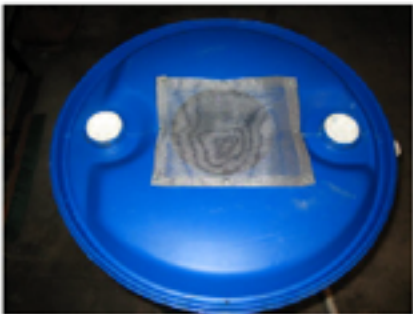
Outdoor shower???

Simple Gray Water Recycling System

- "Small and slow solutions"
- Daily reminder of the value of freshwater
- Participation in the systems that sustain us

Community Project Share

A Pattern Language (1977)

- "Towns and buildings will not be able to become alive, unless they are made by all the people in society, and unless these people share a common pattern language, within which to make these buildings, and unless this common pattern language is alive itself."

- "The elements of this language are entities called patterns. Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without every doing it the same way twice."

- South facing outdoors:
  - Always place buildings to the north of the outdoor spaces that go with them, and keep the outdoor spaces to the south. Never leave a deep band of shade between the building and the sunny part of the outdoors.

- Sunny place:
  - The area immediately outside the building, to the south – that angle between its walls and the earth where the sun falls – must be developed and made into a place which lets people bask in it.

- Half-hidden garden:
  - If a garden is too close to the street, people won't use it because it isn't private enough. But if it is too far from the street, then it won't be used either, because it is too isolated.
  - Do not place the garden fully in front of the house, nor fully to the back. Instead, place it in some kind of half-way position, side-by-side with the house, in a position which is half-hidden from the street, and half-exposed.

- Garden growing wild:
  - A garden which grows true to its own laws is not a wilderness, yet not entirely artificial either.
  - Grow grasses, mosses, bushes, flowers, and trees in a way which comes close to the way that they occur in nature: intermingled, without barriers between them, without bare earth, without formal flower beds, and with all the boundaries and edges made in rough stone and brick and wood which become a part of the natural growth.

- Compost:
  - Our current ways of getting rid of sewage poison the great bodies of natural water, and rob the land around our buildings of the nutrients they need.

- Green house:
  - In temperate climates, build a greenhouse as part of your house or office, so that it is both a "room" of the house which can be reached directly without going outdoors and a part of the garden which can be reached directly from the garden.

- Vegetable garden:
  - Set aside one piece of land either in the private garden or on common land as a vegetable garden. About one-ten of an acre is needed for each family of four. Make sure the vegetable garden is in a sunny place and central to all the households it serves. Fence it in and build a small storage shed for gardening tools beside it.

- Roof garden:
  - A vast part of the earth's surface, in a town, consists of roofs. Couple this with the fact that the total area of a town which can be exposed to the sun is finite, and you will realize that it is natural, and indeed essential, to make roofs which take advantage of the sun and air.
  - Make parts of almost every roof system usable as roof gardens. Make these parts flat, perhaps terraced for planting, with places to sit and sleep, private places. Place the roof gardens at various stories, and always make it possible to walk directly out onto the roof garden from some lived-in part of the building.

- Terraced slope:
  - On sloping land, erosion caused by runoff can kill the soil. It also creates uneven distribution of rainwater over the land, which naturally does less for plant life than it could if it were evenly distributed. On all land which slopes – make a system of terraces which follow the contour lines.
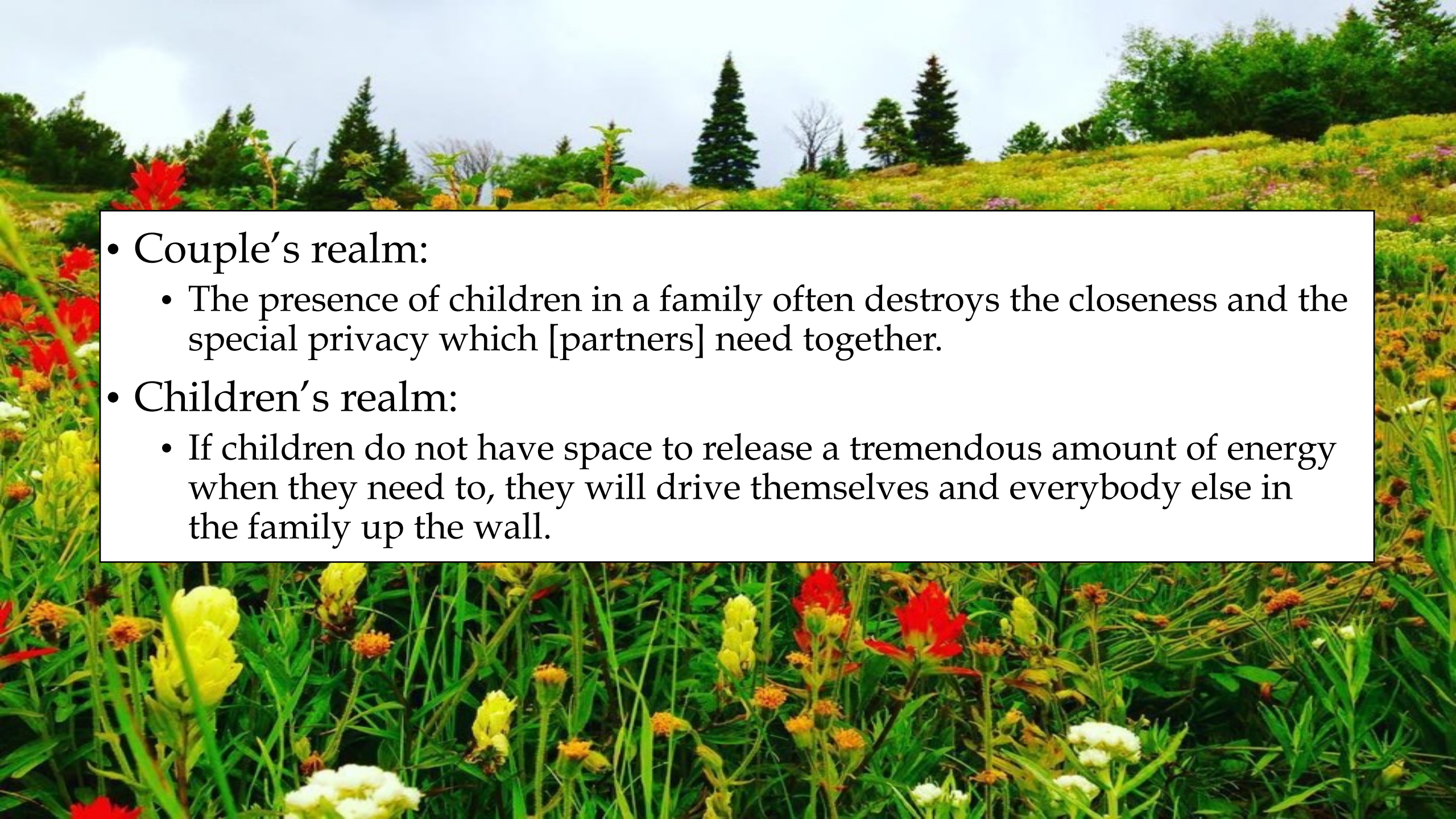
- Trellised walk:
  - Where paths need special protection or where they need some intimacy, build a trellis over the path and plant it with climbing flowers. Use the trellis to help shape the outdoor spaces on either side of it.

- Intimacy gradient:
  - Unless the spaces in a building are arranged in a sequence which corresponds to their degrees of privateness, the visits made by strangers, friends, guests, clients, family, will always be a little awkward.
  - Lay out the spaces of a building so that they create a sequence which begins with the entrance and the most public parts of the building, then leads into the slightly more private areas, and finally to the most private domains.

- Couple's realm:
  - The presence of children in a family often destroys the closeness and the special privacy which [partners] need together.
- Children's realm:
  - If children do not have space to release a tremendous amount of energy when they need to, they will drive themselves and everybody else in the family up the wall.
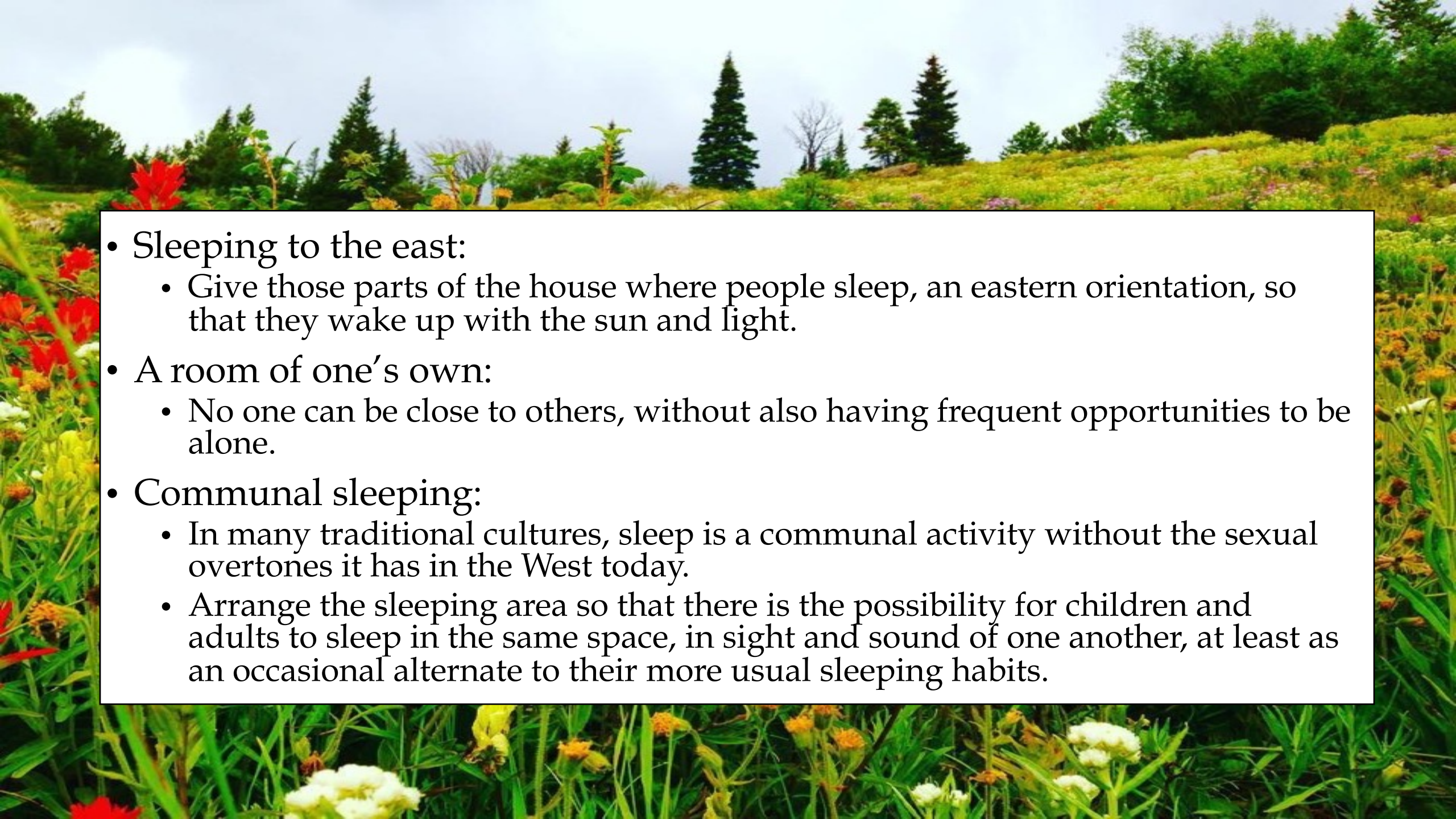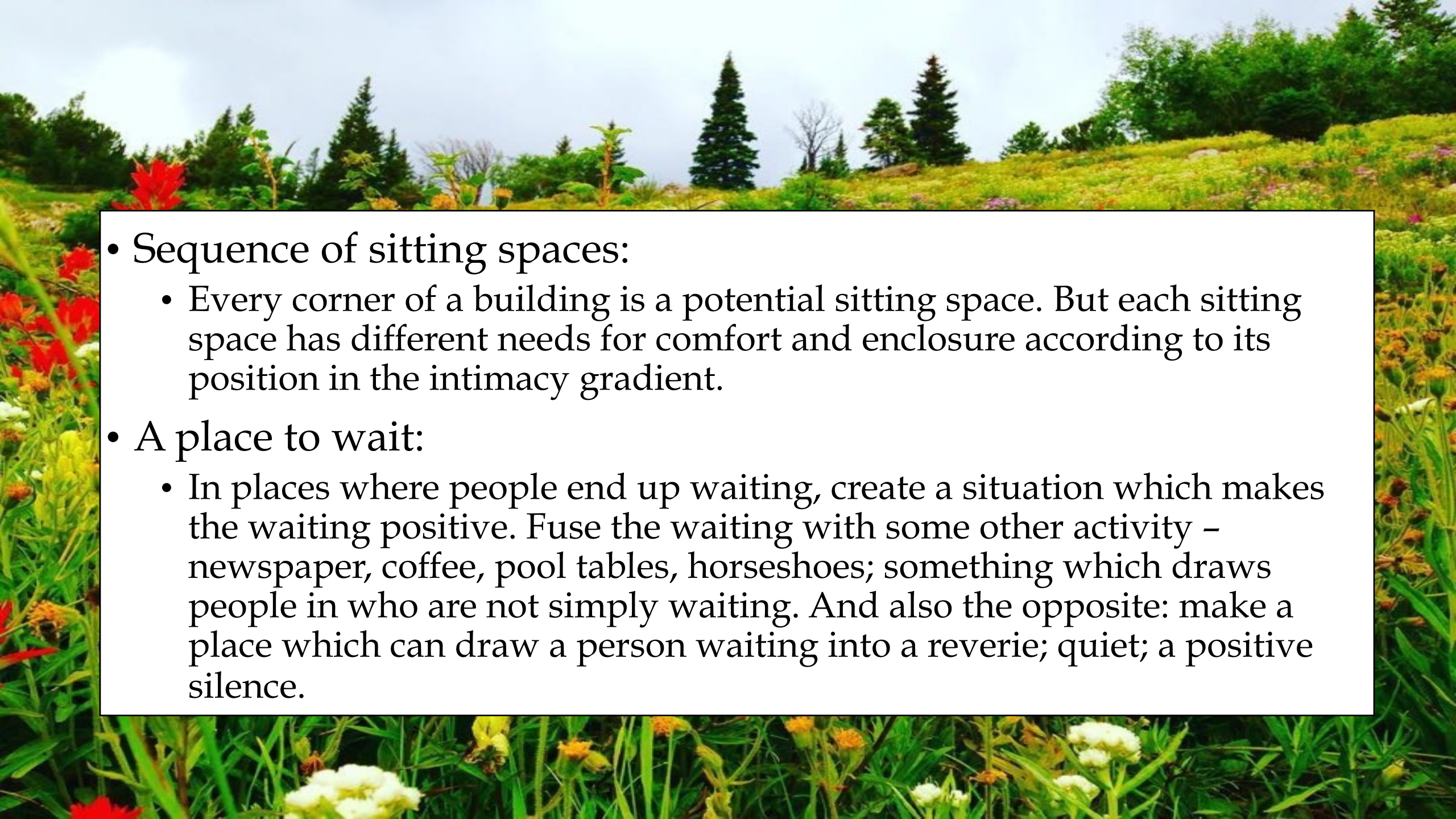
- Common areas at the heart:
  - No social group – whether a family a work group, or a school group – can survive without constant informal contact among its members.
  - Create a single common area for every social group. Locate it at the center of gravity of all the spaces the group occupies, and in such a way that the paths which go in and out of the building lie tangent to it.

- Bulk storage:
  - In houses and workplaces there is always some need for bulk storage space; a place for things like suitcases, old furniture, old files, boxes – all those things which you are not ready to throw away, and yet not using everyday.

- Sleeping to the east:
  - Give those parts of the house where people sleep, an eastern orientation, so that they wake up with the sun and light.

- A room of one's own:
  - No one can be close to others, without also having frequent opportunities to be alone.

- Communal sleeping:
  - In many traditional cultures, sleep is a communal activity without the sexual overtones it has in the West today.
  - Arrange the sleeping area so that there is the possibility for children and adults to sleep in the same space, in sight and sound of one another, at least as an occasional alternate to their more usual sleeping habits.

- Sequence of sitting spaces:
  - Every corner of a building is a potential sitting space. But each sitting space has different needs for comfort and enclosure according to its position in the intimacy gradient.
- A place to wait:
  - In places where people end up waiting, create a situation which makes the waiting positive. Fuse the waiting with some other activity – newspaper, coffee, pool tables, horseshoes; something which draws people in who are not simply waiting. And also the opposite: make a place which can draw a person waiting into a reverie; quiet; a positive silence.

- Small work groups:
  - People will feel oppressed, both when they are either working in an undifferentiated mass of workers and when they are forced to work in isolation. The small group achieves a nice balance between the one extreme in which there are so many people, that there is no opportunity for an intimate social structure to develop, and the other extreme in which there are so few, that the possibility of social groups does not occur at all.

- Home workshop:
  - As the decentralization of work becomes more and more effective, the workshop in the home grows and grows in importance.

- Garden seat:
  - Make a quiet place in the garden – a private enclosure with a comfortable seat, thick planting, sun.
- Window place:
  - Everybody loves window seats, bay windows, and big windows with low sills and comfortable chairs drawn up to them.
  - In every room where you spend any length of time during the day, make at least one window into a "window place."

- Eating atmosphere:
  - Put a heavy table in the center of the eating space – large enough for the whole family or the group of people using it. Put a light over the table to create a pool of light over the group, and enclose the space with walls or with contrasting darkness. Make the space large enough so the chairs can be pulled back comfortably, and provide shelves and counters close at hand for things related to the meal.

- Communal eating:
  - Without communal eating, no human group can hold together.

- Sitting circle:
  - Place each sitting space in a position which is protected, not cut by paths or movement, roughly circular, made so that the room itself helps to suggest the circle – not too strongly – with paths and activities around it, so that people naturally gravitate toward the chairs when they get into the mood to sit. Place the chairs and cushions loosely in the circle, and have a few too many.

- Different chairs:
  - People are different sizes; they sit in different ways. And yet there is a tendency in modern times to make all chairs alike.
  - Never furnish any place with chairs that are identically the same. Choose a variety of different chairs, some big, some small, some softer than others, some rockers, some very old, some new, with arms, without arms, some wicker, some wood, some cloth.

Pattern Activity

Questions?