The structure of plant communities

• Observing and describing vegetation
• Community structure and diversity
• Species richness
• Dominance hierarchies
• A field example
What shapes plant communities?

- How do plant communities vary in space?
- And change in time?
What shapes plant communities?

- What are the internal and external causes of the variation in vegetation states?
Observing plant communities

• How do we describe plant communities?
• What do we measure?
• How do we sample?
Sampling plant communities

- Sampling shape
  - transects
  - quadrats
  - Points along line

- Sample size
  - depends on plant and patch size
  - plant density
  - minimal sample area assumed to capture most or all species in the entire assemblage (*problematic!*)

- Sample placement
  - regular, contiguous,
  - random, stratified
  - depending on landscape patchiness
Sampling scale

- Arbitrary sampling (random)
  *reflects patchiness implicitly, but ignores patch-specific differences*

- Stratified sampling (random sets)
  *within different patch types, ≥ 2*

- Regular sampling (grids or lines)
  *captures both patchiness and differences*

- Two spatial scales (*spatial ‘window of observation’*)
  - Resolution (*grain – smallest unit of observation*)
  - Extent (*scope – largest actually observed area*)

*can be extended by nested hierarchy of replication*
Describing plant communities

- Physical structure
  - Dimensions
    horizontal and vertical
  - Biomass
    above- and below-ground
  - Abundance
    plant density, cover

- Biodiversity
  - Number of species
    or other taxa or functional groups
  - Abundance per species or functional group

*Most commonly used is species diversity*
Biodiversity

Individual plants within communities

➢ Taxonomic groups
  • Species, genera, (sub)families, orders

➢ Functional groups
  • Primary producers, litter producers, N-fixers

➢ Species traits
  • By developmental, morphological and physiological characteristics

➢ Species responses
  • To various environmental factors

➢ Life-forms
  • Herbs (perennial/annual graminoids and forbs, incl. legumes), woody plants (sub-shrubs, shrubs, trees, rosette trees), vines, stem-succulents, epiphytes

  • Raunkiaer’s (1907) life-form spectra based on location of renewal buds: Phanerophytes, Chamaephytes, Hemicryptophytes, Cryptophytes, Therophytes
Other forms of biodiversity

Other levels of organization

- Genetic diversity
  - of genotypes or genes
  - within and among populations

- Biochemical, metabolomic diversity (?)
  - within organisms, populations, communities

- Landscape diversity
  - Landscape patches
  - Successional stages
  - Physical and biogeochemical gradients
Physical structure

- Abundance
  - Plant density
  - Total biomass
  - Ground cover (aerial, basal)

- Canopy layers
  (Synusia)

Continuous variables (scalars)

*Straightforward comparisons between communities*
Species diversity

Species richness
(number of different species)

Abundance hierarchies
(differences in abundance added)

Species composition
(species identities added)

Species incidence-abundance
(spatial distribution of species added)
Species richness

- Number of species depends on sample size (density/sample)

![Graph showing species richness vs. number of individuals](resampling.png)

![Graph showing seed traps in herbaceous communities](seed_traps.png)

- and on area

![Graph showing Mauritius trees](mauritius_trees.png)

- Correction for density
- Fisher’s α
- Rarefaction

(equal resampling from all samples)
Species richness increases with area due to

- Greater number of individuals sampled (sample size N)
- More different habitats (patch types)
- "Provincial" effects (entering a different biome)
Cumulative species-area curves

The way S increases with area depends on:

- The mean number of species per sample,
- The similarity between samples and
- The incidence (presence) of the species among the samples
Abundance

• Abundance hierarchies and rank dominance
  • Dominant and subordinate species
    ➢ Based on importance values $p_i = n_i/N$ of species i

  • Models assuming an underlying species abundance distribution
    ➢ Used for Fisher’s α to correct species number for density
Dominance structure

• Diversity indices
  ➢ Simpson: $D = 1/(\Sigma p_i^2)$
  ➢ Shannon: $H = -\Sigma p_i \ln(p_i)$

Indices are combinations of Species number $S$ and Equitability $E, J$

• Equitability (evenness)
  ➢ Simpson: $E = D/S = (1/(\Sigma p_i^2))/S$
  ➢ Shannon: $J = H/\ln(S) = - (\Sigma p_i \ln(p_i))/\ln(S)$

Great Basin shrubland  Chihuahuan Desert scrub
Equitability

- Reflects dominance structure
- Simpson’s $E$ and Shannon’s $J$ reflect different aspects:
  - $\Delta E$ - differences in dense species (dominants)
  - $\Delta J$ - differences in sparse (subordinate) or dominant, but not intermediate species

![Graph showing the relationship between species importance ($p_i$) and equitability measures ($Y = f(p_i)$).](image)

Measures of vegetation structure

• Physical variables
  - Plant density $N$, Total biomass, Ground cover
  - Measure overall structure

*Scale-independent scalars: pooling = averaging*

• Species richness
  - Species number $S$, Density-corrected $S_d$, Rarefaction, Fisher’s $\alpha$
  - Measure diversity within samples

*Scale-dependent vectors: pooling ≠ averaging*

• Equitability
  - Simpson’s $E$ and Shannon’s $J$
  - Measure dominance structure within samples
  - Comparisons show differences due to dense or sparse species

*Scale-dependent vectors: pooling ≠ averaging*
A field example

Three patch types
- 1x0.3m samples
- 20 replications

Matrix
- few plants and species
- abundant dominants, sparse species equitable

Mounds
- denser and richer in species
- less dominance

Pits
- also denser and richer in species
- sparse species less equitable