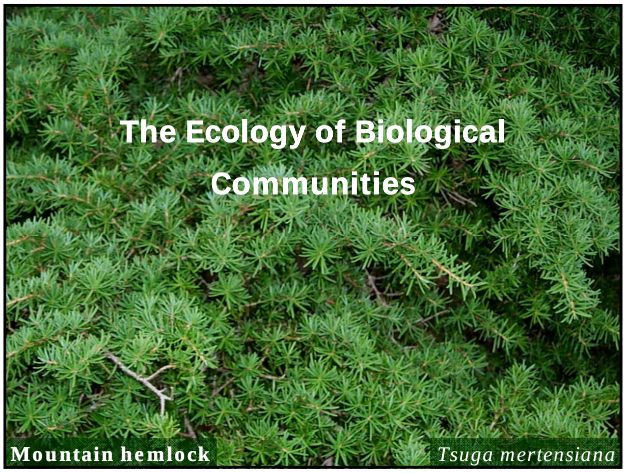
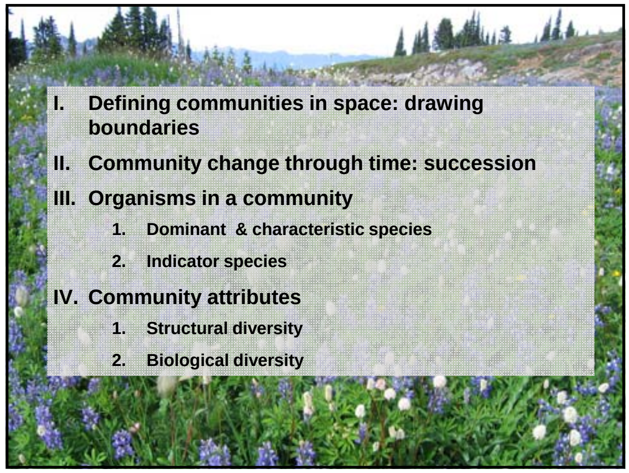


The Ecology of Biological Communities

Mountain hemlock *Tsuga mertensiana*



I. Defining communities in space: drawing boundaries
II. Community change through time: succession
III. Organisms in a community
    1. Dominant & characteristic species
    2. Indicator species
IV. Community attributes
    1. Structural diversity
    2. Biological diversity

How do we define the boundaries of a community?

Humans & Boxes: The unnatural nature of boundaries in nature

We will examine 2 types of boundaries:

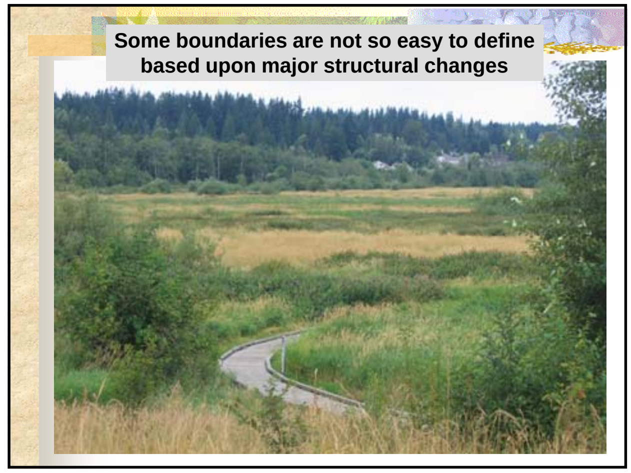
1. Boundaries in space
   - Where does one community / ecosystem stop and another start?
   - What causes things to change through space?
2. Boundaries in time
   - Where does one community / ecosystem stop and another start?
   - What causes things to change through time?

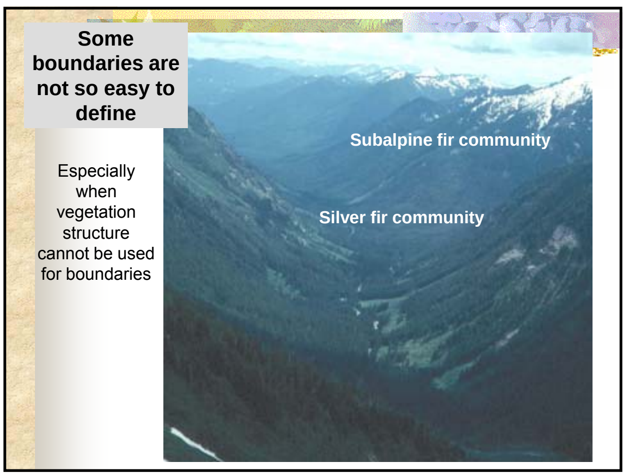
Some boundaries are easy to define

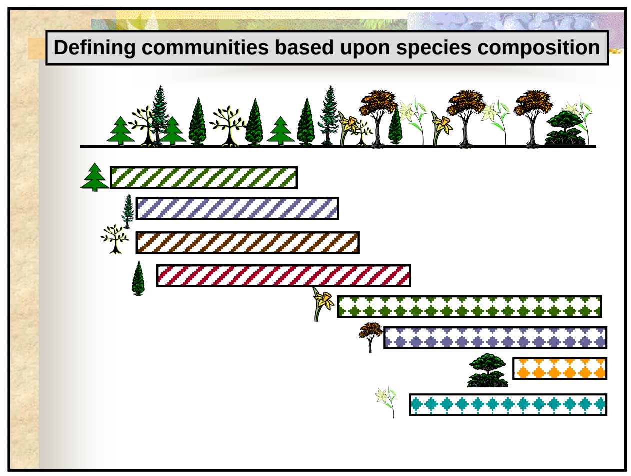
Other boundaries are not so easy to draw

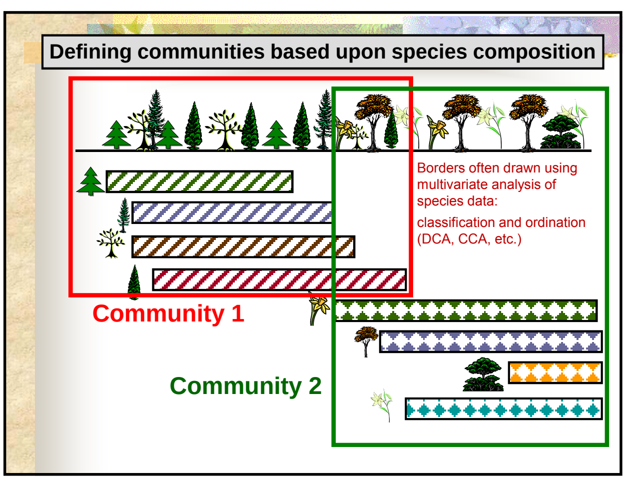
March 2006

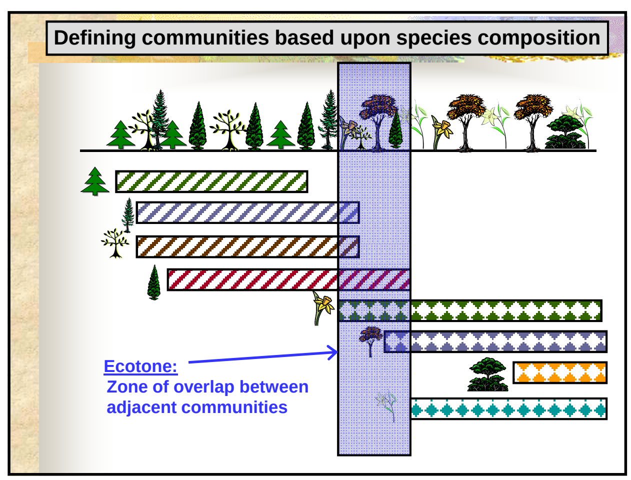

Vegetation structure as a means of creating boundaries

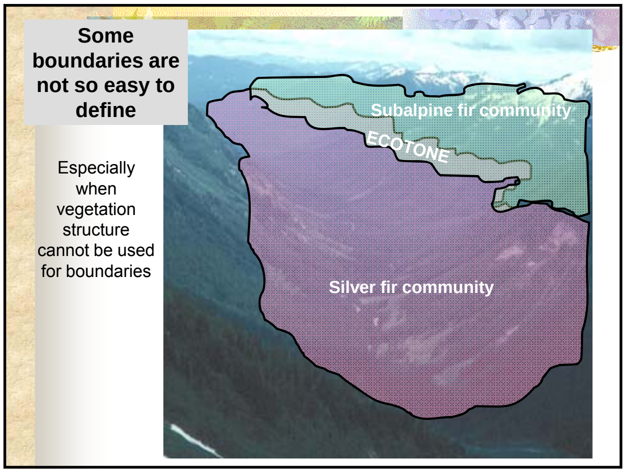

Some boundaries are not so easy to define based upon major structural changes

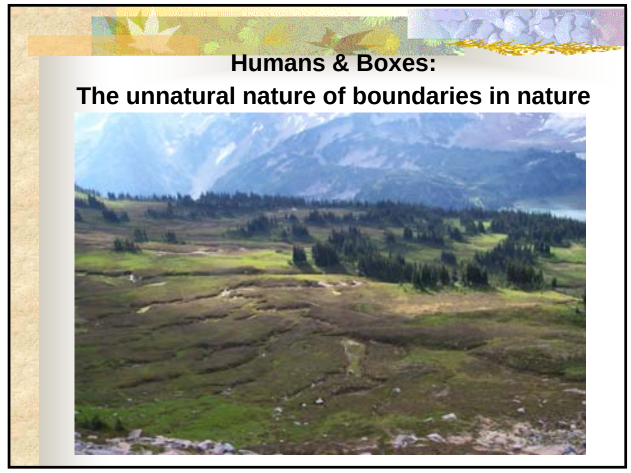

Some boundaries are not so easy to define
Especially when vegetation structure cannot be used for boundaries
Subalpine fir community
Silver fir community


Defining communities based upon species composition

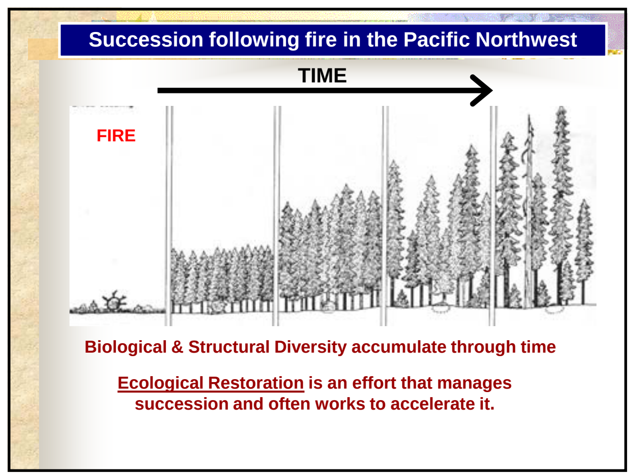

Defining communities based upon species composition
Borders often drawn using multivariate analysis of species data:
classification and ordination (DCA, CCA, etc.)
Community 1
Community 2

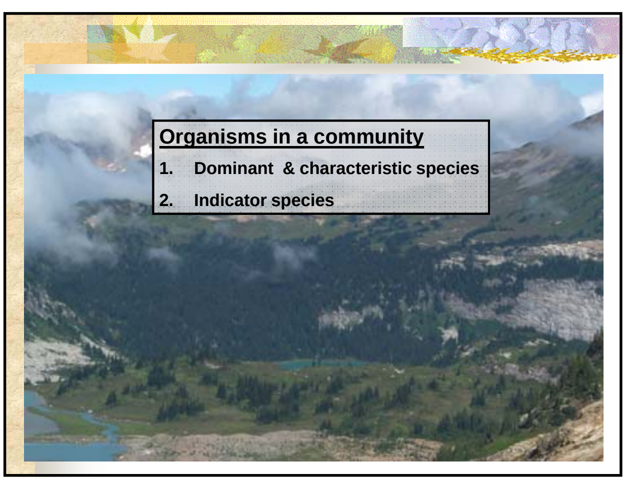

Defining communities based upon species composition
Ecotone:
Zone of overlap between adjacent communities

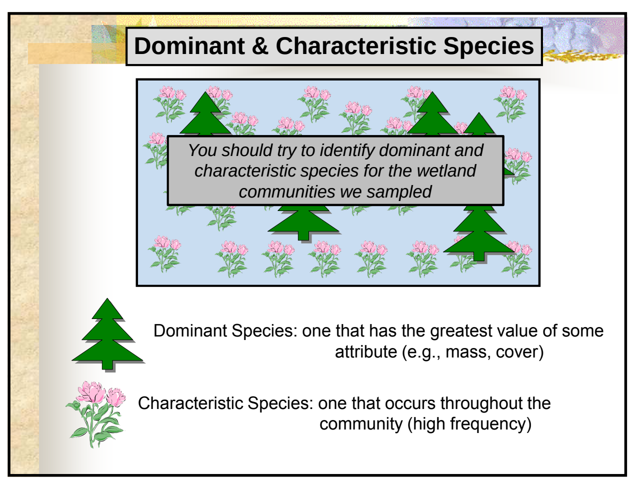

Some boundaries are not so easy to define
Especially when vegetation structure cannot be used for boundaries
Subalpine fir community
ECOTONE
Silver fir community


Humans & Boxes:
The unnatural nature of boundaries in nature


Community Change through Time
Succession: long-term changes in communities through TIME
Lyman Glacier Basin
North Cascades


Succession following fire in the Pacific Northwest
TIME
FIRE
Biological & Structural Diversity accumulate through time
Ecological Restoration is an effort that manages succession and often works to accelerate it.


Organisms in a community
1. Dominant & characteristic species
2. Indicator species


Dominant & Characteristic Species
You should try to identify dominant and characteristic species for the wetland communities we sampled
Dominant Species: one that has the greatest value of some attribute (e.g., mass, cover)
Characteristic Species: one that occurs throughout the community (high frequency)

Indicator Species

It can be challenging to understand physical & chemical environments

How wet is it? Where? When? How would you sample?

Indicator Species

Plants integrate the environment in TIME & SPACE

Indicator Species

Species with a narrow tolerance of some environmental factor;

and thus whose presence indicates something about that environmental factor

Indicator Species

Official US Wetland Indicator Status Categories

Category	% Chance species is in a wetland
Wetland Obligate	> 99 %
Fac – wet Species	67 - 99 %
Facultative Species	33 - 66 %
Fac – upland Species	1 - 32 %
Upland Species	< 1 %

Indicator Species

Which are the good INDICATOR SPECIES?

Category	% Chance species is in a wetland
Wetland Obligate	> 99 %
Upland Species	< 1 %

You should use the wetland indicator status of your plants to interpret the environment of the two communities sampled.

Where to get indicator information?

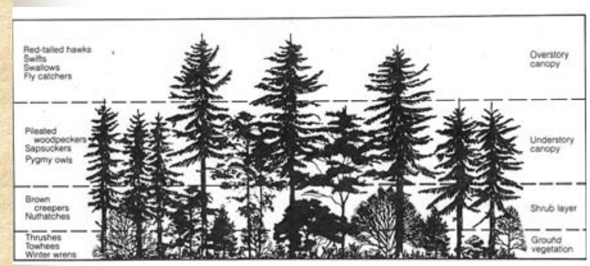
- Handout
- Sarah Cooke's wetland plants book
- References on lab handout

Community attributes

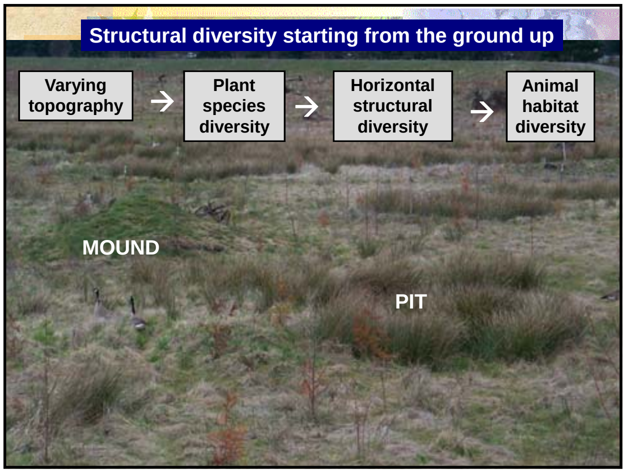
1. Structural diversity
2. Biological diversity

Structural diversity promotes biotic diversity

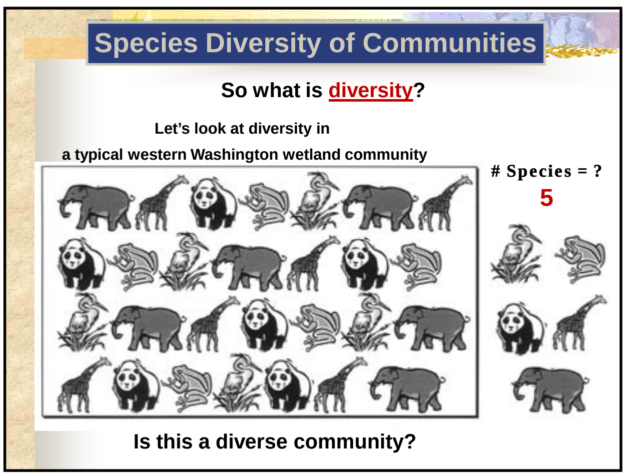
Forest structural complexity (layers, gaps) → Habitat diversity → Animal diversity

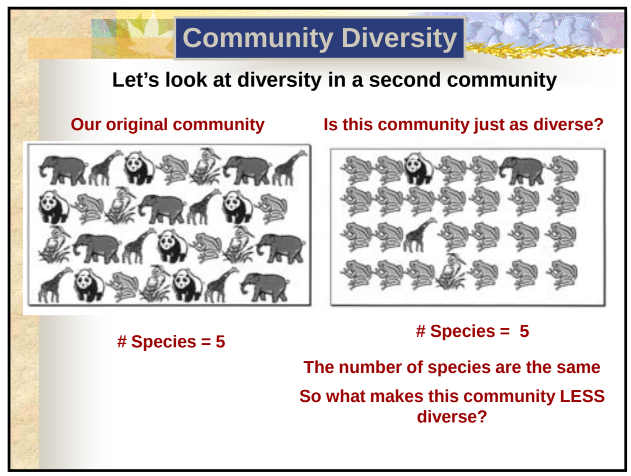


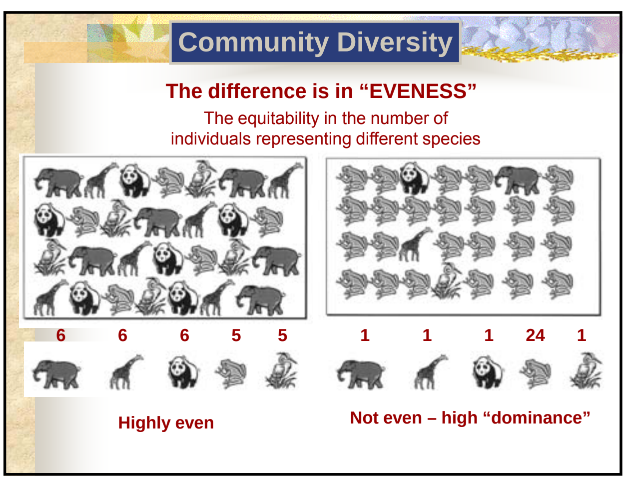
Kruckeberg (1991)

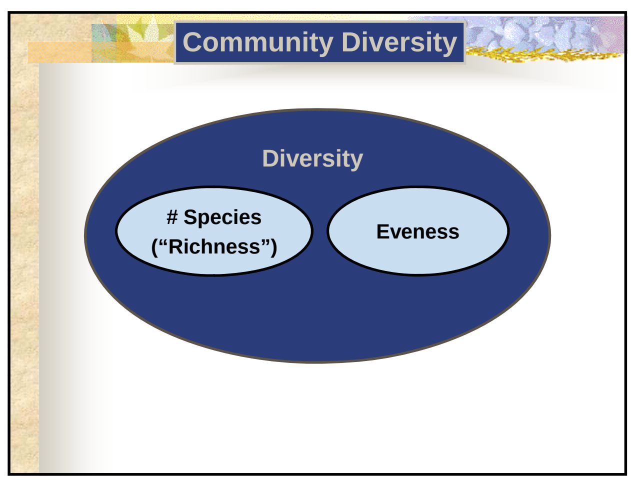

Structural diversity starting from the ground up
Varying topography
Plant species diversity
Horizontal structural diversity
Animal habitat diversity
MOUND
PIT


Let's look more closely at what we mean when we say "BIOLOGICAL DIVERSITY"


Species Diversity of Communities
So what is diversity?
Let's look at diversity in
a typical western Washington wetland community
Species = ?
5
Is this a diverse community?


Community Diversity
Let's look at diversity in a second community
Our original community
Is this community just as diverse?
Species = 5
Species = 5
The number of species are the same
So what makes this community LESS diverse?

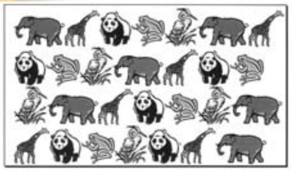

Community Diversity
The difference is in "EVENESS"
The equitability in the number of individuals representing different species
6
6
6
5
5
1
1
1
24
1
Highly even
Not even – high "dominance"

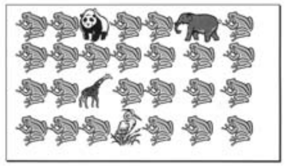

Community Diversity
Diversity
Species ("Richness")
Eveness

Community Diversity

Diversity encompasses concepts of

richness and eveness





Is diversity always desirable?

Good community ?

Bad community ?

Quantifying Biological Diversity

1. Richness
2. Dominance / Eveness
3. Diversity

Quantifying Biological Diversity

1. Richness How do we quantify species richness?

Plot 1	Plot 2
Acer macrophyllum	*Acer macrophyllum*
Alnus rubra	*Alnus rubra*
Carex obnupta	*Carex dewyana*
Corylus cornuta	*Juncus effusus*
Juncus effusus	*Lonicera involucrata*
Physocarpus capitatus	*Physocarpus capitatus*
Poa praetensis	*Thuja plicata*

What is the species richness of plot 1? **7**

What is the species richness of plot 2? **7**

What is the species richness of the whole community? **10**

Quantifying Biological Diversity

2. Dominance / Eveness

Simpson's index of dominance (C)

$$C = \Sigma (p_i)^2$$

p_i is the fractional representation of one species in the whole cover of a community

$$p_i = \frac{\text{\% cover of one species}}{\text{total \% cover of all species in a community}}$$

Calculating Simpson's index of dominance (C)

$$C = \Sigma (p_i)^2$$

Species	% Cover
R. discolor	20
R. parviflorus	13
S. douglasii	35
A. macrophyllum	8
G. elata	3

Calculating Simpson's index of dominance (C)

$C = \Sigma (p_i)^2$

Step 1: Calculate total community cover

Species	% Cover
R. discolor	20
R. parviflorus	13
S. douglasii	35
A. macrophyllum	8
G. elata	3
Total cover	**79**

Calculating Simpson's index of dominance (C)

$C = \Sigma (p_i)^2$

Step 2: Calculate p_i values for each species

Species	% Cover	p_i
R. discolor	20	0.25
R. parviflorus	13	0.16
S. douglasii	35	0.44
A. macrophyllum	8	0.10
G. elata	3	0.04
Totals	**79**	**1.00**

20 / 79 = 0.25

These fractional values should sum to 1.0 !

Calculating Simpson's index of dominance (C)

$C = \Sigma (p_i)^2$

Step 3: Square each p_i value

Species	% Cover	p_i	p_i^2
R. discolor	20	0.25	0.064
R. parviflorus	13	0.16	0.027
S. douglasii	35	0.44	0.196
A. macrophyllum	8	0.10	0.010
G. elata	3	0.04	0.001
Totals	**79**	**1.00**	

Calculating Simpson's index of dominance (C)

$C = \Sigma (p_i)^2$

Step 4: Sum the squares of the p_i values

Species	% Cover	p_i	p_i^2
R. discolor	20	0.25	0.064
R. parviflorus	13	0.16	0.027
S. douglasii	35	0.44	0.196
A. macrophyllum	8	0.10	0.010
G. elata	3	0.04	0.001
Totals	**79**	**1.00**	**0.299**

C

The significance of Simpson's index of dominance (C)

$C = \Sigma (p_i)^2$

Significance of the Shannon – Wiener diversity index (H')

$H' = - \Sigma [(p_i)(\ln p_i)]$

- **Theoretical values range from 0 to 1.0**
- **Higher values indicate a less even (more dominated) community**
- **C < 0.5 is a relatively even community**
- **Most values in campus wetlands have been between 0.15 and 0.5**

Quantifying Biological Diversity

3. Species Diversity

Note that this is actually called "α diversity" by ecologists (you should have encountered β diversity and γ diversity in an ecology course)

Quantifying Biological Diversity

3. Species Diversity

Shannon – Wiener Index of Diversity (H')

$H' = -\Sigma [(p_i)(\ln p_i)]$

p_i is the fractional representation of one species in the whole cover of a community

$$p_i = \frac{\text{\% cover of one species}}{\text{total \% cover of all species in a community}}$$

Calculating the Shannon – Wiener diversity index (H')

$H' = -\Sigma [(p_i)(\ln p_i)]$

Species	% Cover
R. discolor	20
R. parviflorus	13
S. douglasii	35
A. macrophyllum	8
G. elata	3

Quantifying Biological Diversity

Calculating the Shannon – Wiener diversity index (H')

$H' = -\Sigma [(p_i)(\ln p_i)]$

Step 1: Calculate total community cover

Species	% Cover
R. discolor	20
R. parviflorus	13
S. douglasii	35
A. macrophyllum	8
G. elata	3
Total cover	**79**

Calculating the Shannon – Wiener diversity index (H')

$H' = -\Sigma [(p_i)(\ln p_i)]$

Step 2: Calculate p_i values for each species

Species	% Cover	p_i
R. discolor	20	0.25
R. parviflorus	13	0.16
S. douglasii	35	0.44
A. macrophyllum	8	0.10
G. elata	3	0.04
Totals	**79**	**1.00**

20 / 79 = 0.25

These fractional values should sum to 1.0 !

Calculating the Shannon – Wiener diversity index (H')

$H' = -\Sigma [(p_i)(\ln p_i)]$

Step 3: Calculate the ln p_i values for each species

Species	% Cover	p_i	ln p_i
R. discolor	20	0.25	-1.37
R. parviflorus	13	0.16	-1.80
S. douglasii	35	0.44	-0.81
A. macrophyllum	8	0.10	-2.29
G. elata	3	0.04	-3.27
Totals	**79**	**1.00**	

Calculating the Shannon – Wiener diversity index (H')

$H' = -\Sigma [(p_i)(\ln p_i)]$

Step 4: Multiply the last two columns: (pi) x (ln p_i)

Species	% Cover	p_i	ln p_i	p_i * ln p_i
R. discolor	20	0.25	-1.37	-0.348
R. parviflorus	13	0.16	-1.80	-0.297
S. douglasii	35	0.44	-0.81	-0.361
A. macrophyllum	8	0.10	-2.29	-0.232
G. elata	3	0.04	-3.27	-0.124
Totals	**79**	**1.00**		

Calculating the Shannon – Wiener diversity index (H')

$H' = -\Sigma [(p_i)(\ln p_i)]$

Step 5: Sum that last column: (pi) x (ln p_i)

Species	% Cover	p_i	ln p_i	p_i * ln p_i
R. discolor	20	0.25	-1.37	-0.348
R. parviflorus	13	0.16	-1.80	-0.297
S. douglasii	35	0.44	-0.81	-0.361
A. macrophyllum	8	0.10	-2.29	-0.232
G. elata	3	0.04	-3.27	-0.124
Totals	**79**	**1.00**		**- 1.362**

Calculating the Shannon – Wiener diversity index (H')

$H' = -\Sigma [(p_i)(\ln p_i)]$

Step 6: Reverse the sign of that sum

Species	% Cover	p_i	ln p_i	p_i * ln p_i
R. discolor	20	0.25	-1.37	-0.348
R. parviflorus	13	0.16	-1.80	-0.297
S. douglasii	35	0.44	-0.81	-0.361
A. macrophyllum	8	0.10	-2.29	-0.232
G. elata	3	0.04	-3.27	-0.124
Totals	**79**	**1.00**		**1.362**

H'

Significance of the Shannon – Wiener diversity index (H')

$H' = -\Sigma [(p_i)(\ln p_i)]$

- Theoretical values range from 0 to infinity
- H' > 7 is an extremely diverse community
- H' > 2 is a highly diverse community
- H' < 1 is a low diversity community
- Most values in campus wetlands have been between 1 and 2

Wetland Vegetation Analysis

Using your data and the data from the other group

Examine
- Species
- Growth form cover
- Species richness
- Species eveness / dominance
- Species diversity

1. Compare the two communities based upon transect data
2. Compare the two communities based upon quadrat data
3. Compare the two sampling techniques

Wetland Vegetation Analysis

Oral Presentation: Tuesday, April 20

Written Report: Tuesday, April 27

Wetland Vegetation Analysis

Oral Presentation: Tuesday, April 20

- As a group, give a 20 minute presentation of results FROM YOUR GROUP ONLY and preliminary conclusions
- All students must participate
- PowerPoint Format
- Create intentional, logical, explicit STRUCTURE
- Grading will be by group

Wetland Vegetation Analysis

Written Report: Tuesday, April 27

- Can be submitted as an individual or group project – your choice.
- Results & Discussion section
- Results from your group and other group
- More discussion than oral report – particularly based upon information about major species found (see field guides and links on lab handout to ecological information on common species)
- No page guidelines, but more than 4 - 6 pages of text would surprise me (not including figures).