**Landscape metrics:**

Mixed prairie and juniper woodland, western North Dakota

**Quantifying landscape diversity**

**Reading: Chapter 5**

Types of landscape metrics:

1. Patch area (patch number, patch density, total patch type area, core area)
2. Patch perimeter (edge density, total patch length, edge contrast)
3. Patch shape (perimeter to area ratio, elongation index, shape indices, fractal dimension)
4. Core area metrics (core area is defined as the area within a patch beyond some specified edge distance or buffer width)

Types of landscape metrics (continued):

5. Diversity and Evenness (proportional area of patch types)
6. Isolation/proximity indices (deals with the spatial context of the patch, not the patches themselves; nearest neighbor, proximity)
7. Contrast metrics (refers to the magnitude of difference between adjacent patch types with respect to attributes)
8. Interspersion metrics (tendency of aggregation)
9. Connectivity (refers to the degree to which a landscape facilitates/impedes ecological flows)

**What is meant by the term "Biological diversity" or "Biodiversity"?**

**Biological diversity** is the variety of life and its processes; and includes the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur (Keystone Report 1991).

**Many Diversity Indices have been developed to account for the variation in both the number of taxa and the distribution of abundance among taxa. In almost all cases the indices have two components:**

**1) richness**

**2) equitability of abundance**

With respect to landscape diversity 'richness' refers to ?

And 'abundance' refers to?

**Landscape diversity results from two superimposed influences:**

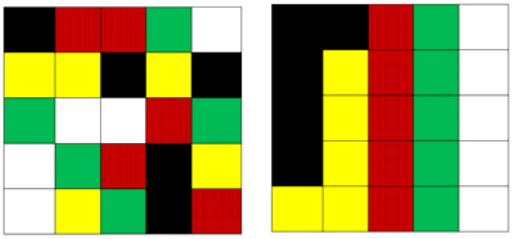
**1) the vegetation pattern of distribution of communities along gradients of environmental conditions, limiting factors and resources, and**

**2) the patterns of disturbance and recovery (succession) within the communities along the gradients**

**NOTE: Important to remember that it is the individual species that are responding to the environmental and successional gradients.**

Source: Romme and Knight 1982

Which of these landscapes has greater diversity with respect to cover type?



Colors refer to different vegetation cover types.

## Diversity indices:

**Shannon-Wiener Diversity Index**

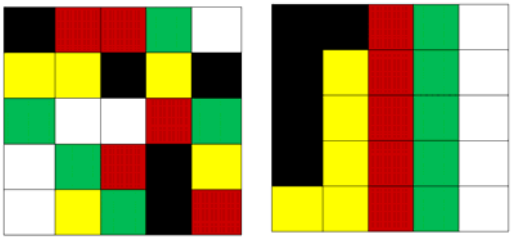
**H' or SHDI = $-\Sigma p_i \ln p_i$**

**Range= SHDI>0, theoretically without limit (in reality < 8)**

**Remember: When these indices are applied to landscapes, they are a measure related to polygon types (cover type, land use, ownership, etc.) not species.**

**Note: $p_i$ = proportion of the ith community type in the landscape.**

## Calculate the Shannon-Wiener Diversity Index (H')



$p_{black}$ = ?
$p_{red}$ = ?
$p_{yellow}$ = ?
$p_{green}$ = ?
$p_{white}$ = ?

$\ln p_{black} = \ln 0.2$ = ?

**$H' = -\Sigma p_i \ln p_i$**

## Diversity indices:

**Simpson's Diversity Index**

**$\lambda = \Sigma p_i^2$ for an infinite sample**

**Range = $0 \leq \lambda < 1$: highest diversity when $\lambda$ approaches 0**

**Note: $p_i$ = proportion of the *i*th community type in the landscape,**

## Diversity indices:

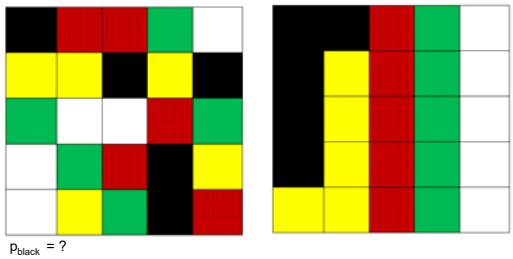
**Simpson's DI is commonly transformed:**

**$1-\lambda$ or SIDI = $1- \Sigma p_i^2$**

**Range = $0 < 1-\lambda < 1$**

**Now the maximum diversity occurs when $1-\lambda$ approaches 1.**

Calculate the Transformed Simpson's Diversity Index ($1 -\lambda$)



$p_{black}$ = ?
$p_{red}$ = ?
$p_{yellow}$ = ?
$p_{green}$ = ?
$p_{white}$ = ?

**$1- \lambda = 1-\Sigma p_i^2$**

## Calculation

$1 - \lambda = 1 - \Sigma p_i^2$

Calculations for Black:
pi= 0.2
Pi squared = 0.04

Calculations for landscape:
0.04 x 5 = 0.20
1 – 0.20 = 0.80

## Evenness indices:

**Simpson's Evenness Index =**
$[\Sigma p_i^2] / \ln m$ ← m = species or community richness

**Shannon's Evenness Index =**
$-\Sigma p_i \ln p_i / \ln m$

**Range = 0 ≤ All evenness indices ≤ 1**
**Evenness increases as index approaches 1 where all elements (species, or communities) are uniformly abundant**

**Example landscapes: 1000 ha**
**Which landscape has the highest diversity?**

| Community type (CT) | Landscape A (reference) | Landscape B (more even) | Landscape C (Uniform) | Landscape D (more CTs) |
|---|---|---|---|---|
| A | 500 | 250 | 143 | 500 |
| B | 200 | 200 | 143 | 200 |
| C | 100 | 200 | 143 | 100 |
| D | 100 | 150 | 143 | 100 |
| E | 50 | 100 | 143 | 10 |
| F | 40 | 60 | 143 | 10 |
| G | 10 | 40 | 142 | 10 |
| H | | | | 10 |
| I | | | | 10 |
| J | | | | 10 |
| K | | | | 10 |
| L | | | | 10 |
| M | | | | 10 |
| N | | | | 9 |
| O | | | | 1 |
| Total | 1000 | 1000 | 1000 | 1000 |

Same number of CTs as A but more evenly distributed

Same general distribution of major CTs as A but has many more rare CTs in landscape

Same number of CTs as A but evenly distributed

(8 more CTs than A, B or C, 100% more)

0.0667
2.7076

**Shannon-Wiener Diversity Index**

**H' or SHDI = $-\Sigma p_i \ln p_i$**

**$SHDI_A$= - (0.5 ln 0.5) + (0.2 ln 0.2) + (0.1 ln 0.1) + (0.1 ln 0.1) + (0.05 ln 0.05) + (0.04 ln 0.04) + (0.01 ln 0.01)**

**= - [(-0.3466) + (-0.3219) + (-0.2302) + (-0.2302) + (-0.1498) + (-0.1288) + (-.0461)]**

**$SHDI_A$= 1.4538**

**$SHDI_B$= 1.8029**
**$SHDI_C$= 1.9459**
**$SHDI_D$= 1.5933**

**What would the H' be if all 15 community types were equally represented in the 1000 unit area landscape?**

**Simpson's Diversity Index**

**$\lambda$ or SIDI = $\Sigma p_i^2$**

**$SIDI_A$= 0.25 + 0.04 + 0.01 + 0.01 + 0.0025 + 0.0016 + 0.0001**

**= 0.3124**

**$SIDI_B$ = 0.1802**
**$SIDI_C$ = 0.1428**
**$SIDI_D$ = 0.3111**

Increasing diversity, Richness constant, More uniform distribution

**Recall that Simpson's DI is commonly transformed by subtracting $\lambda$ from 1:**

**$1 - \lambda = 1 - \Sigma p_i^2$**

**1 – $SIDI_A$ = 0.6876**
**1 – $SIDI_B$ = 0.8180**
**1 – $SIDI_C$ = 0.8572**
**1 – $SIDI_D$ = 0.6890**

Increasing diversity, Richness constant, More uniform distribution in abundance

**What would 1- $\lambda$ be if all 15 community types were equally represented in the 1000 unit area landscape?**

**Shannon's Evenness Index (SHEI)**

**SHEI = - Σ pi ln pi / ln m**

**$SHEI_A$ = $SHDI_A$ / ln 7**
**= 1.4538 / 1.9459**
**= 0.7471**

**$SHEI_B$ = 0.9265**

**$SHEI_C$ = 1.0000**

Increasing evenness in communities A through C

**$SHEI_D$ = 0.5883**

**(Note: Remember that community richness has increased to 15 in landscape D.)**

**Simpson's Evenness Index**

**$SIEI = [1- \Sigma p_i^2] / [1- (1/m)]$**

Note: When calculating the Transformed Simpson's Evenness Index a different correction is used: [1-(1/m)] rather than ln m.

**$SIEI_A$ = SIDIA / [1- (1/7)]**
**= 0.6858 / 0.8571**
**= 0.8001**

Increasing evenness in communities A through C

**$SIEI_B$ = 0.8198 / 0.8571 = 0.9565**

**$SIEI_C$ = 1.000**

**$SIEI_D$ = 0.6998 / 0.9333 = 0.7498**

**(Note: Remember that community richness has increased to 15 in landscape D.)**

**Summary of diversity indices**

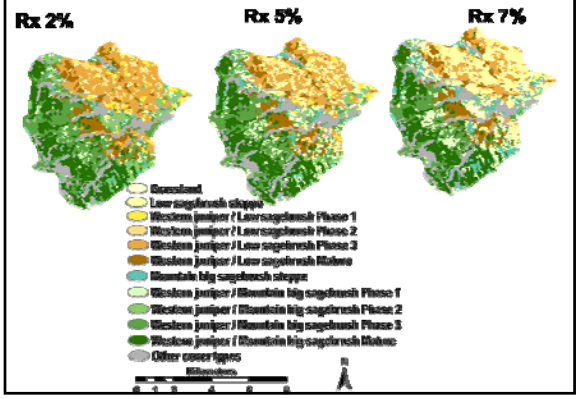
| Diversity metric | Landscape A | Landscape B | Landscape C | Landscape D |
|---|---|---|---|---|
| | Reference community | More even distribution | Uniform distribution | > CT richness |
| Community type richness | 7 | 7 | 7 | 15 |
| Shannon-Wiener DI | 1.4538 | | | 1.5933 |
| Simpson's DI (1-λ) | 0.6876 | 0.8180 | 0.8572 | 0.6890 |
| Shannon-Wiener Evenness Index | 0.7471 | 0.9265 | 1.0000 | 0.5883 |
| Simpson's Evenness Index | 0.8001 | | | 0.7498 |

10% increase with increasing richness

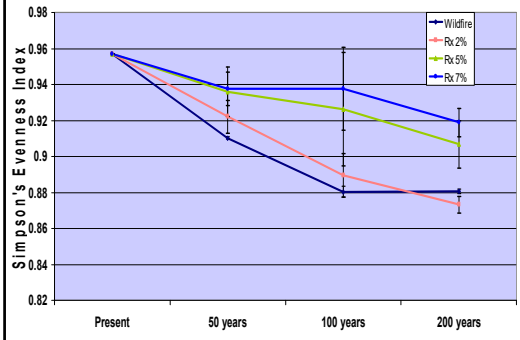
<1% increase with increasing richness

Increasing evenness

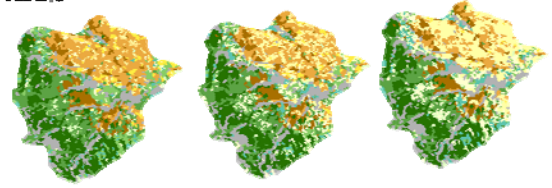
**Prescribed burning scenarios in Smith Creek to maintain sagebrush steppe**




Evenness under a variety of prescribed burn scenarios




**Prescribed burning scenarios in Smith Creek to maintain sagebrush steppe**




What if we have very frequent fires,
what do you think would happen to the evenness?

**Summary Diversity Indices**

- Diversity indices can be a useful measure of temporal changes of a landscape.
- Care must be taken when using landscape diversity indices to compare between landscapes due to the inherent differences of the landscapes. Some landscape are just more naturally diverse than others!
- Evenness indices can be used to reduce the influence of differences of the inherent landscape community richness.
- One must remember that all information related to patch type, and individual patches is lost during these calculations. The same is true for species diversity indices.

Types of landscape metrics (continued):

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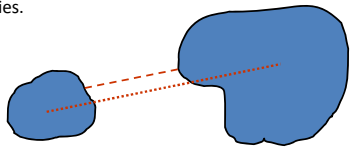
**Nearest neighbor and proximity indices**

1. Nearest neighbor and proximity indices were developed to characterize the distribution of a single patch type on the landscape.
2. These indices have ecological applications related to fragmentation, dispersal of propagules and migration of species.



**Nearest neighbor distance:**

1. It is a simple edge-to-edge distance between patches of the same type.
2. **Mean nearest neighbor** is the corresponding average between each patch and its nearest neighbor of the same type.
3. McGarigal&Marks stress that the mean may not be very useful unless one also has a measure of variation.
4. This index has an obvious relationship with patch density and mean patch size.

**Mean Proximity Index:**

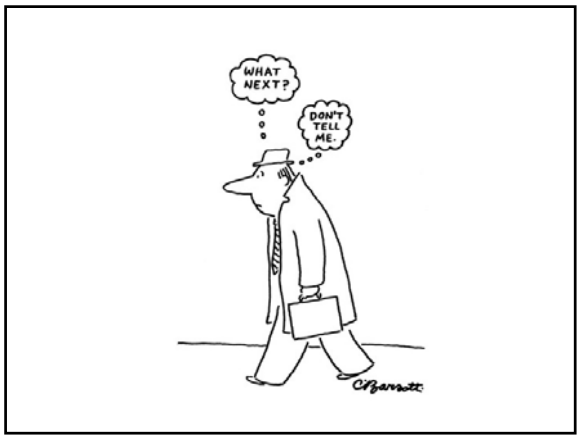
**Mean Proximity Index** = $\sum$ patch area / squared distance to the nearest patch of the same type within a given search radius.

1. Mean Proximity Index considers both the patch size and distance from a focal patch to other patches of the same type that have an edge within a given search radius.
2. This index measures both patch isolation and patch type (class) fragmentation.
3. Larger patches can be farther away and be effective habitat.
4. FRAGSTATS also computes a **Mean Proximity Index** across all patch types in the landscape. However, M&M caution that this metric has not been evaluated for interpretive value.

Summary:

Diversity and Evenness indices can be used to describe the landscape level diversity and evenness of patches. They are based on proportional area of patch types, but do not reflect the location of patches in relation to each other

Isolation/proximity indices quantifies the spatial context of the patch, not the patches themselves; for example nearest neighbor, proximity)


WHAT NEXT?
DON'T TELL ME.