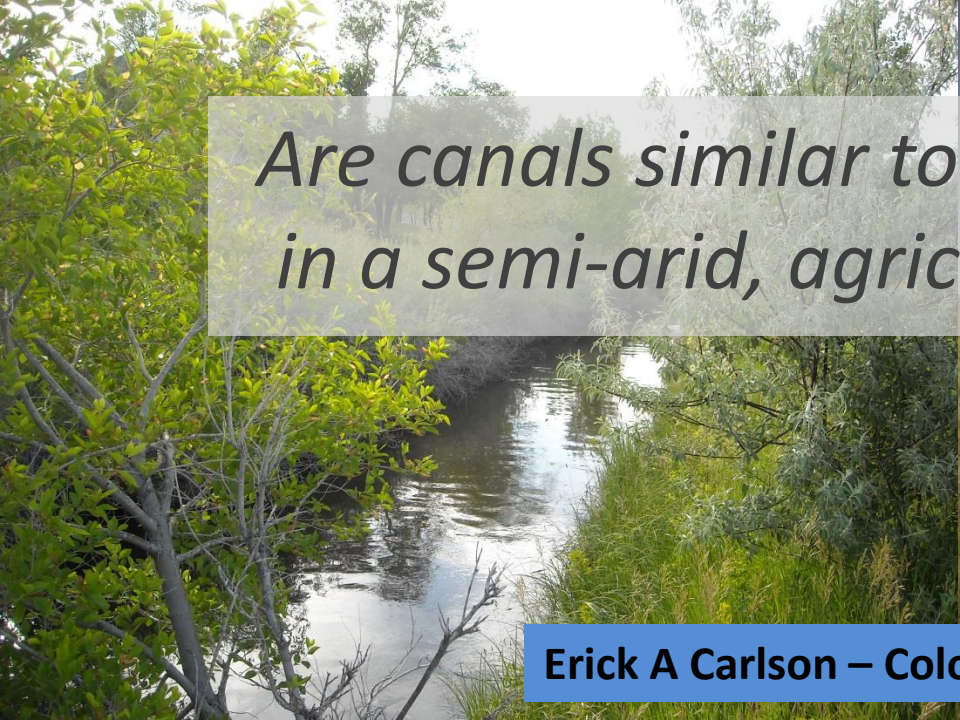




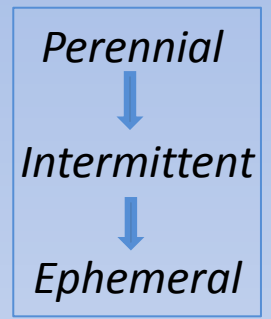
# The New Rivers of the West



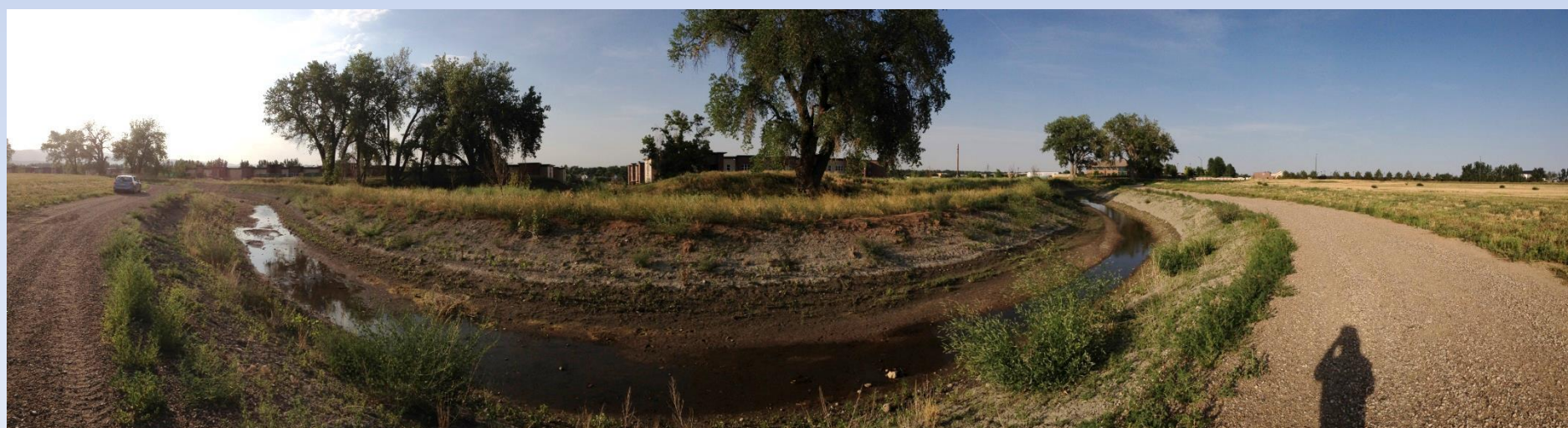
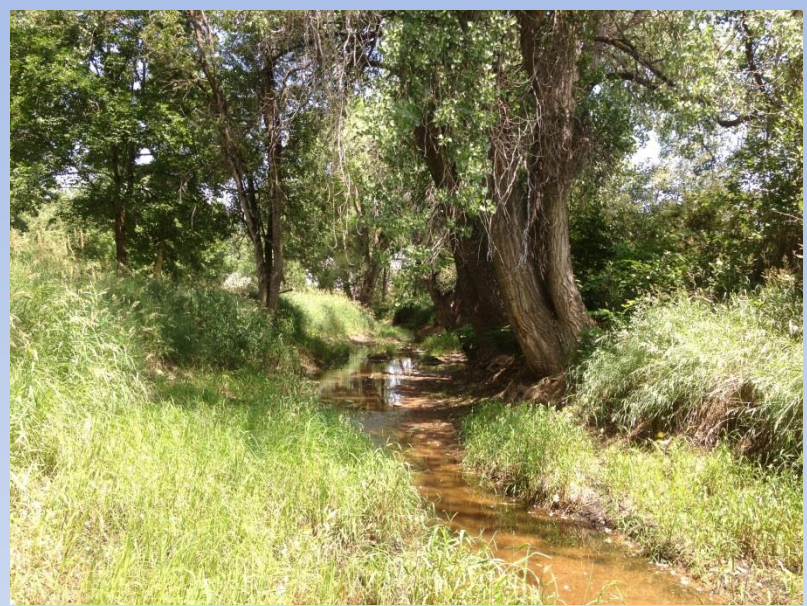
*Are canals similar to rivers and streams in a semi-arid, agricultural landscape?*

# The Result: Degraded Natural Aquatic & Riparian Habitats

- No surprise in the effects of “dewatering”
  - Increased temperature, shift in flow regime
  - Changes in sediment supply and disturbance
  - Invasive species (plant, animal)



# The Result: Novel Aquatic & Riparian Habitats

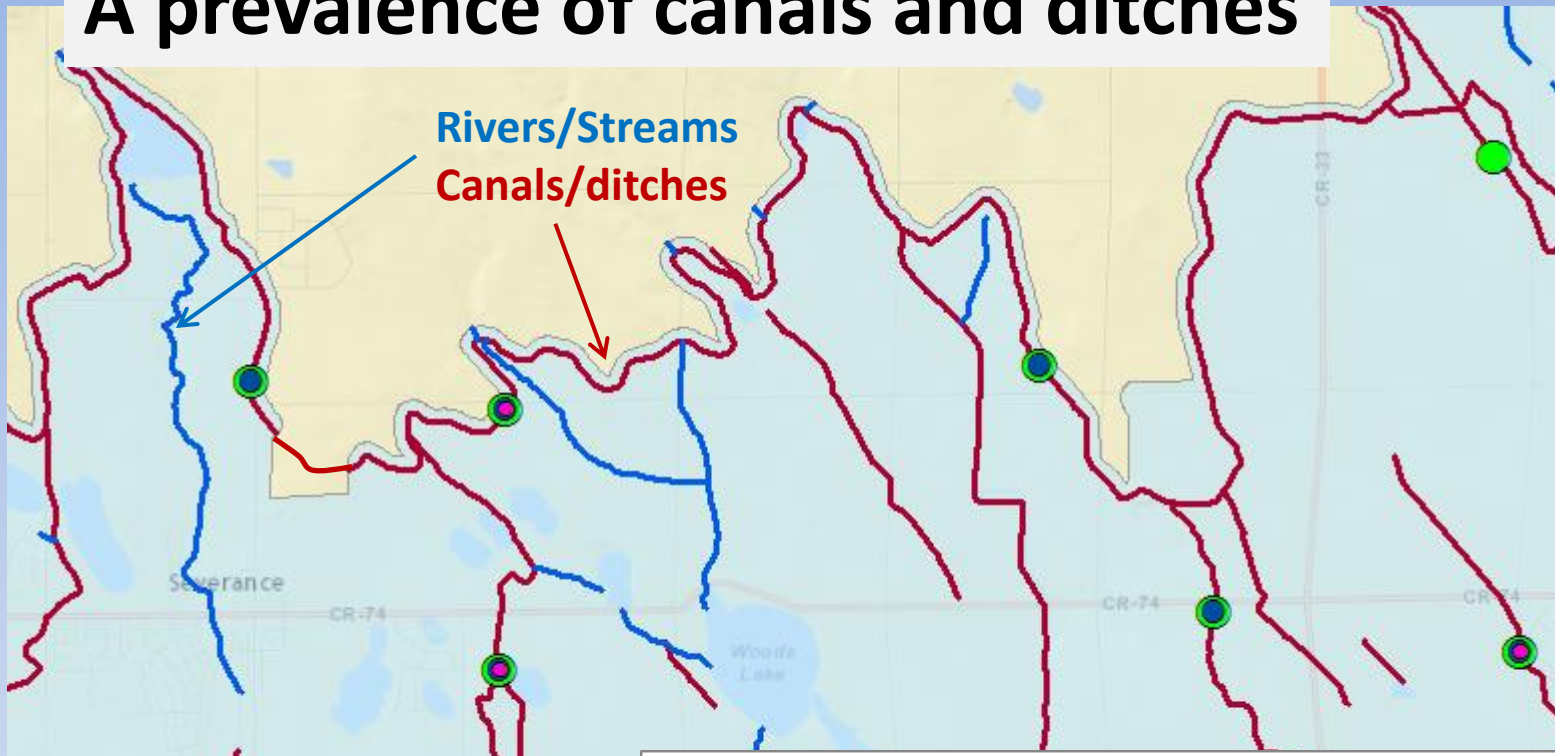


# The Result: Novel Aquatic & Riparian Habitats

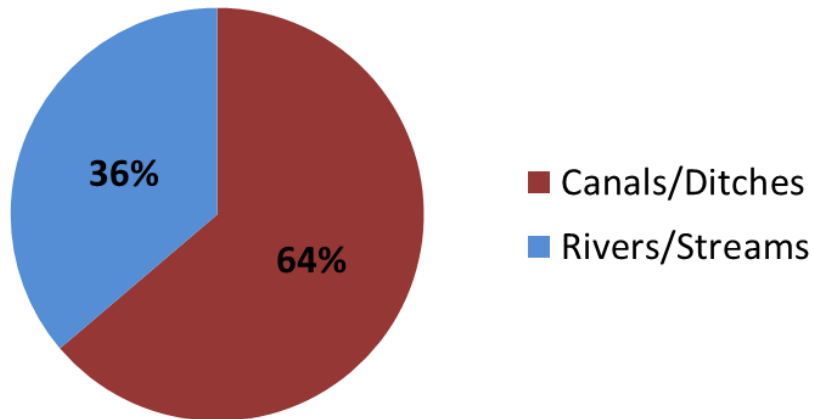
- Same components as rivers and riparian areas
  - Water, plants, sediment, disturbance, insects, birds
- But some key differences
  - Orientation, shape
  - Complete **flow** control
  - Disturbance type
  - **Vegetation**
  - **Aquatic macro-invertebrates**



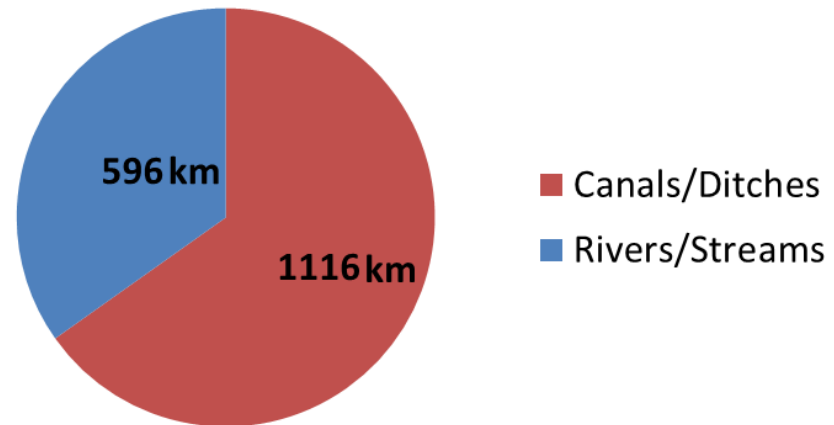
# A prevalence of canals and ditches



### Channel Length Ratio



### City of Boulder Open Space



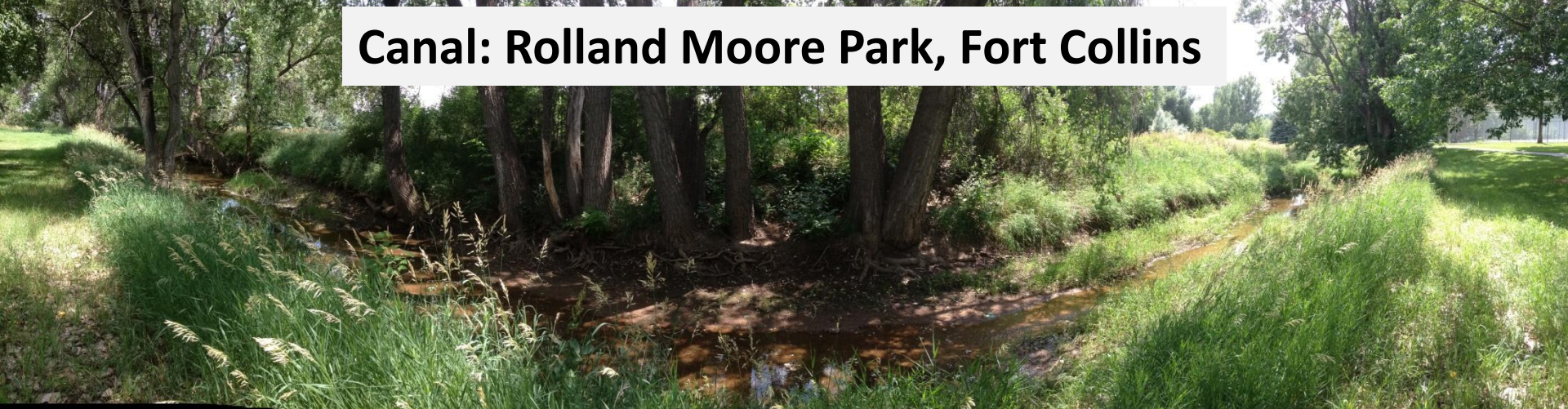
# Major Questions

- Are ditches similar to streams?
  - For the plants?
  - For the aquatic invertebrates?
  - For the growing season flow patterns?
- Is there a regional component?
- Are there geomorphic components?

*Lets play a game*

**Canal? or Stream?**

**Canal: Rolland Moore Park, Fort Collins**



**Stream: Lone Tree Creek, Greeley**



**Canal: Teds Place, Bellvue**





**Willow Creek, Weld County**



**New Mercer Canal, Fort Collins**



**Larimer #2 Canal, Fort Collins**



**Law Slough (canal), Severance**



**Log Canyon Creek, Larimer County**



**Pleasant Valley & Lake Canal**



**A Lateral Ditch, Weld County**

**Pleasant Valley & Lake Canal**

**Spring Creek, Fort Collins**



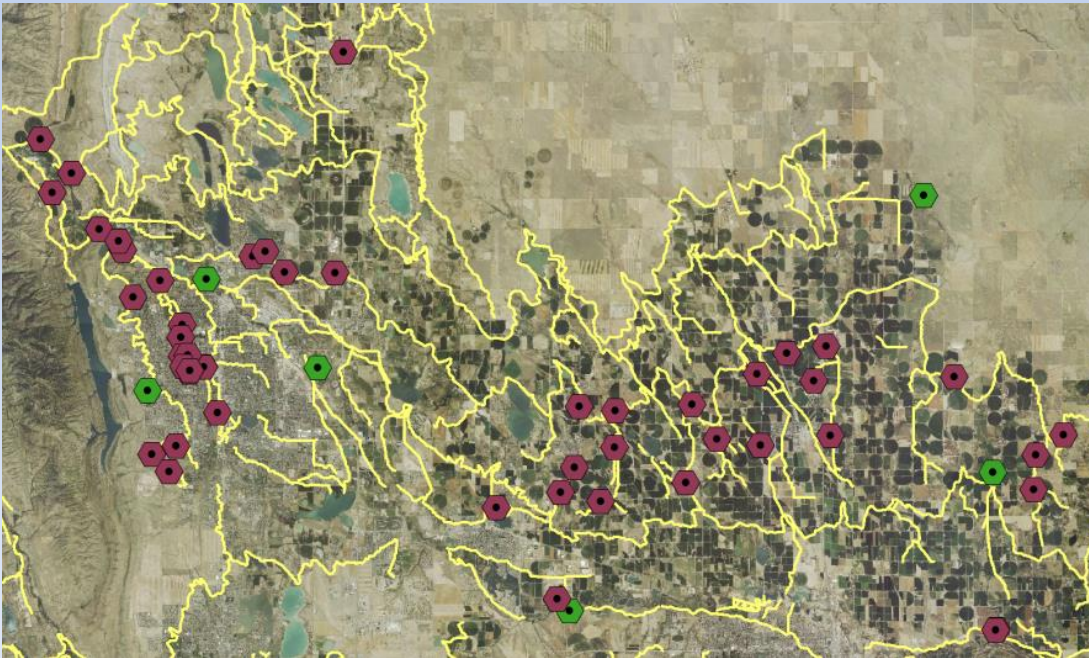
# Take away

- Streams, rivers, canals and ditches *can* look SIMILAR or DIFFERENT
- Do two channels that look a certain way have biological communities to match?

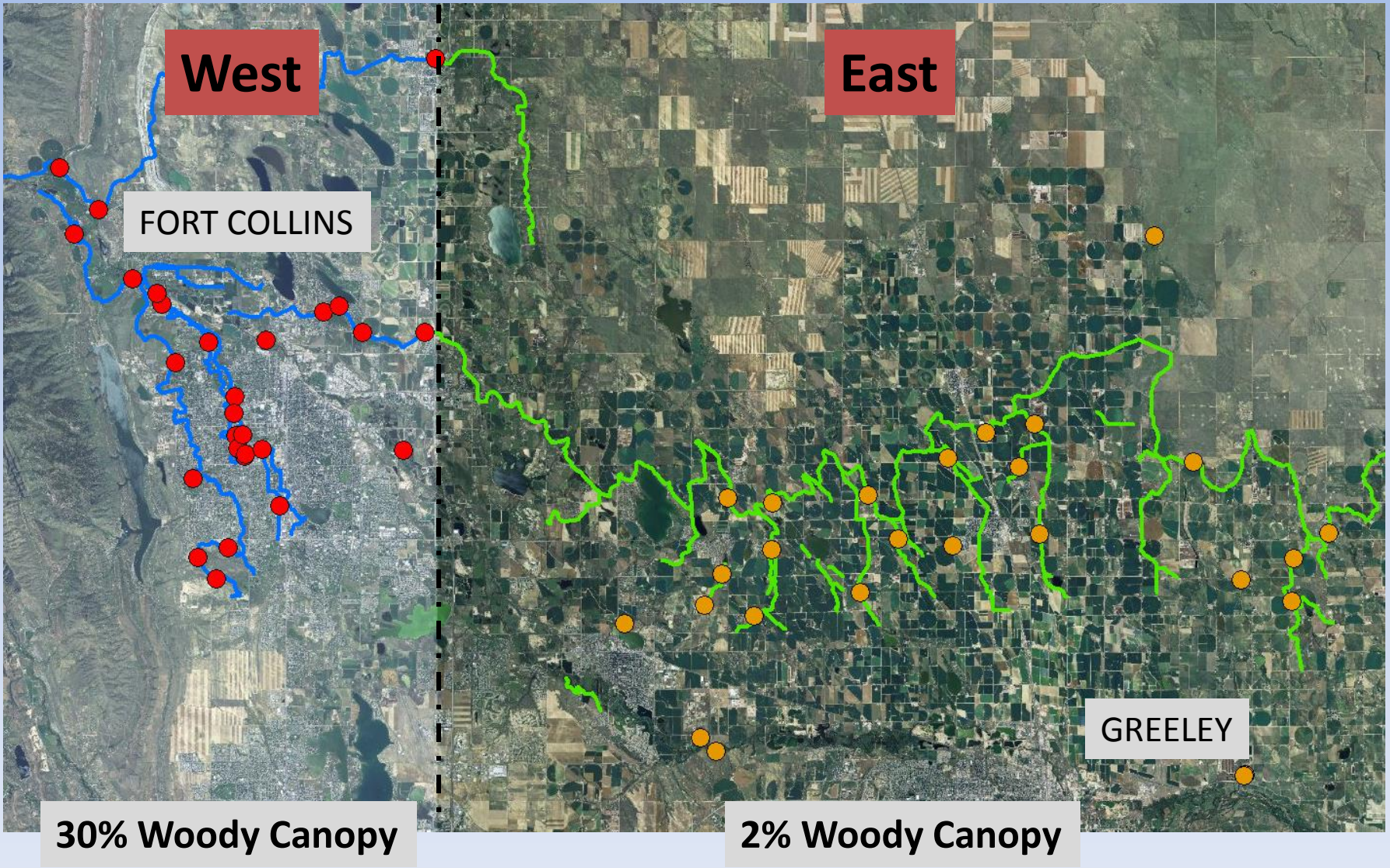


# Categorization & Mapping

- Step 1: Map dominant cover
- Step 2: Points along network proportional to cover ratio



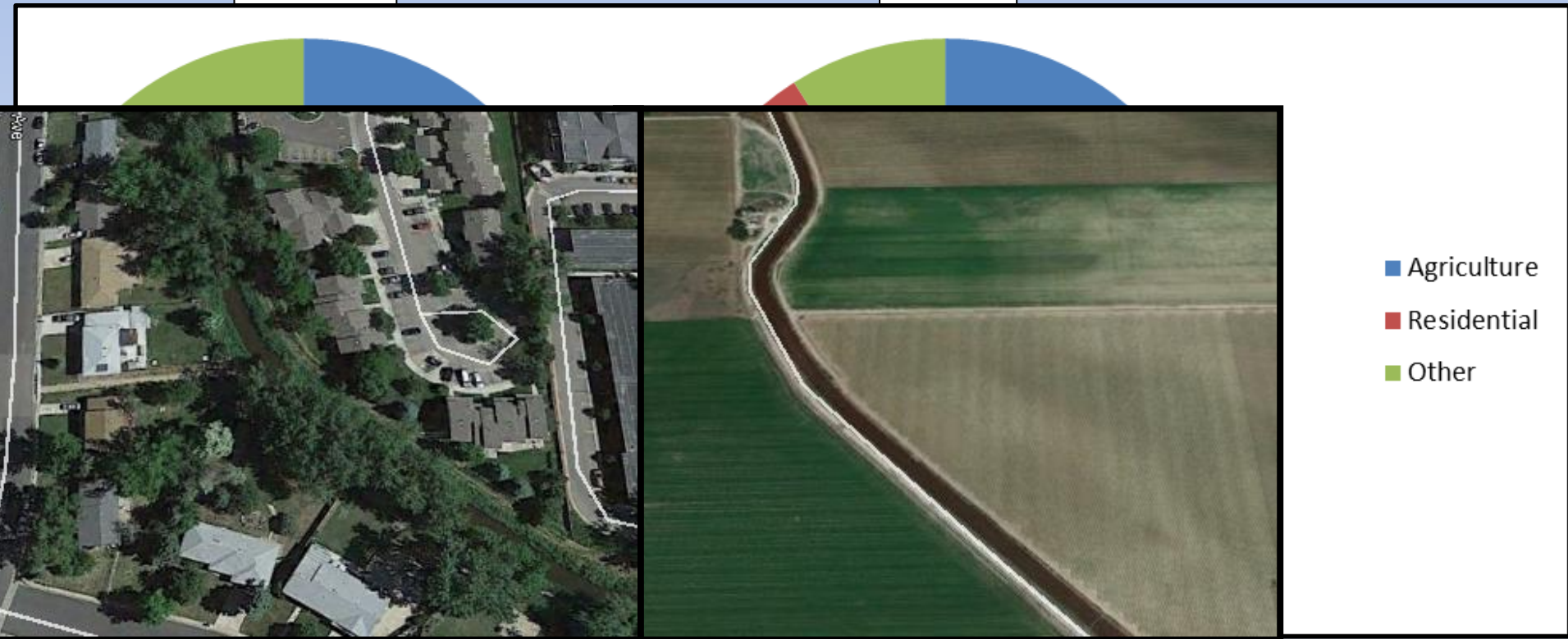
# Study Site Locations



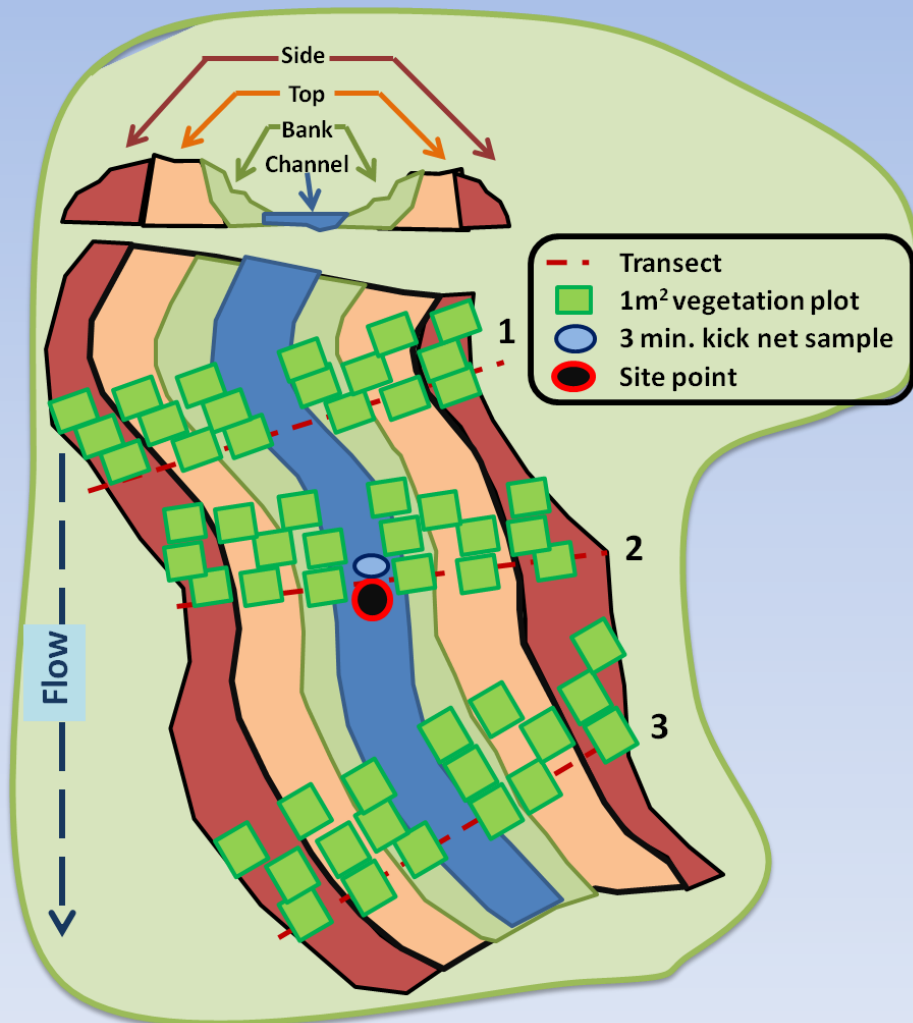
# Landuse within 100m of sites

**West**

**East**



# Field Site Design



**Surveyed 4,477 plots**





# Data Collection- **Benthos**

- Kick Net Sampling
  - Use feet to disturb substrate upstream of net
  - Sweep net under vegetation hanging into water



# Data Collection- Vegetation

- Identify all species present

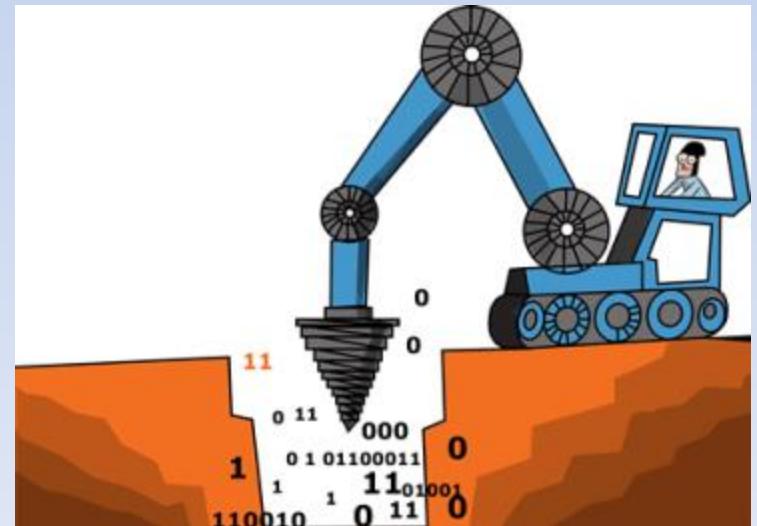


Copyright 2002, University of Illinois



# Data Collection - Hydrology

- Data mining – USGS, CDSS, City of Fort Collins
- Mean daily flow from 1999-2015 (most channels)
- Caveat! Records are from the point of diversion, not at site
- April 1 - September 30

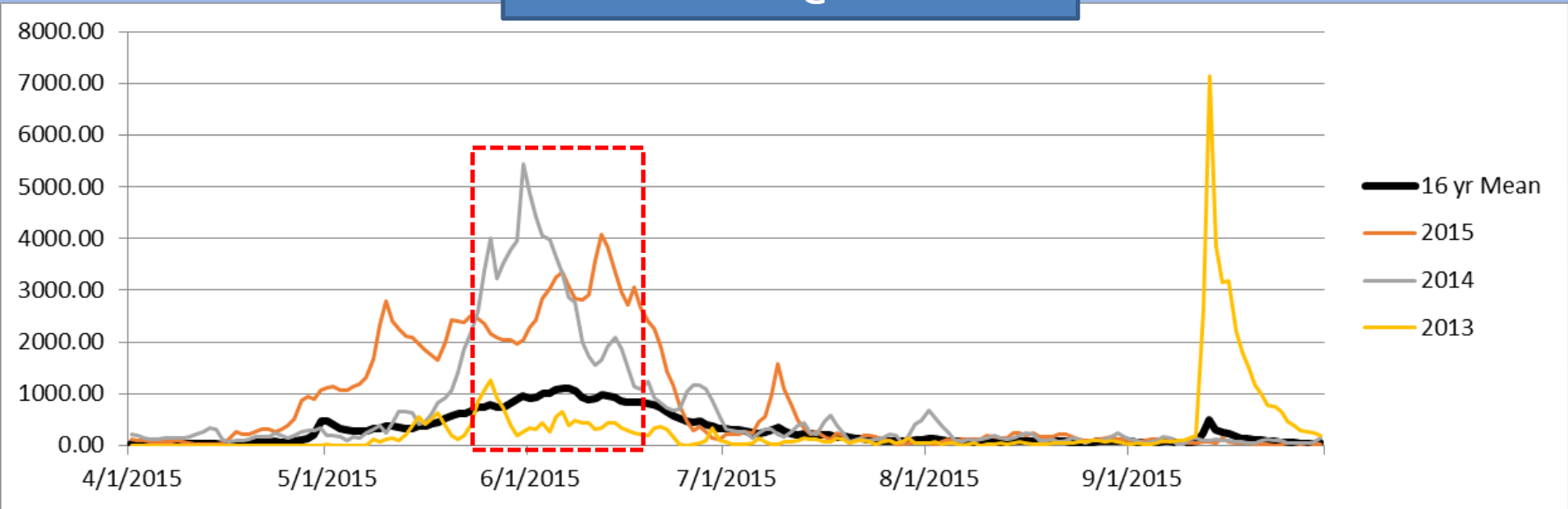


# Hydrologic Metrics

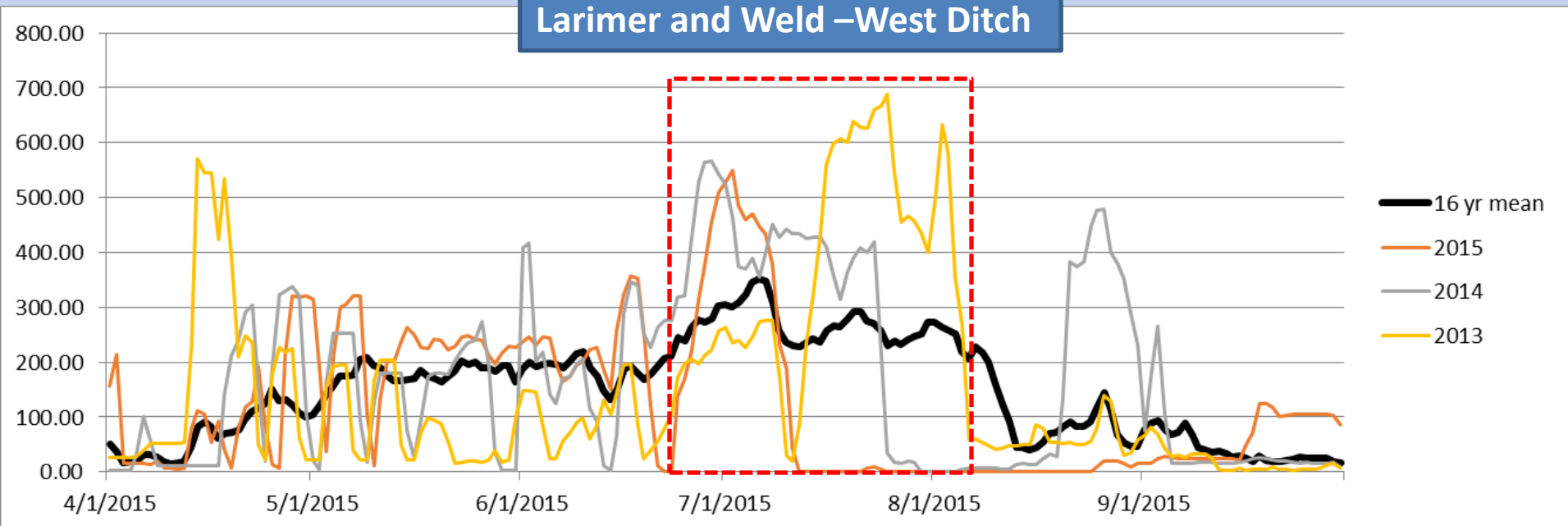
| METRIC                               | Poudre at FoCo | Poudre @ Greeley | Spring Creek@ Taft | Lone Tree Creek | Dry Creek@ Shields | Box Elder@ CR56 | Larimer & Weld | Pleasant Valley&Lake | New Mercer | New Mercer @ Rolland | Larimer #2 |
|--------------------------------------|----------------|------------------|--------------------|-----------------|--------------------|-----------------|----------------|----------------------|------------|----------------------|------------|
| DA / Service Area (km <sup>2</sup> ) |                |                  |                    |                 |                    |                 |                |                      |            |                      |            |
| Years in record                      | 17             | 17               | 3                  | 7               | 3                  | 3               | 17             | 14                   | 17         | 3                    | 17         |
| Daily Skew                           | 2.19           | 3.22             | 4.53               | 5.63            | 1.50               | 4.46            | 1.03           | -0.56                | 0.99       | 1.52                 | 2.03       |
| Daily CV                             | 2.1            | 1.19             | 0.47               | 1.89            | 0.19               | 1.02            | 1.73           | 0.4                  | 1.2        | 1.06                 | 1.73       |
| Daily Mean                           | 295.5          | 237.8            | 15.6               | 11.4            | 1.8                | 12.9            | 150.8          | 26.6                 | 14.0       | 22.6                 | 16.8       |
| TqDailyMean (days)                   | 40             | 29               | 70                 | 47              | 107                | 60              | 72             | 107                  | 67         | 34                   | 44         |
| Median                               | 94.9           | 82.7             | 14.2               | 6.0             | 1.8                | 6.6             | 108.3          | 30.0                 | 8.8        | 13.2                 | 7.0        |
| Daily Max                            | 2289.4         | 1699.0           | 54.1               | 139.1           | 3.4                | 79.8            | 588.1          | 49.8                 | 56.9       | 88.3                 | 105.1      |
| Daily Min                            | 4.90           | 19.94            | 1.92               | 1.09            | 1.33               | 1.26            | 0.90           | 0.46                 | 0.00       | 0.49                 | 0.00       |
| Duration (max 183 days)              | 183            | 182              | 183                | 163             | 183                | 183             | 170            | 168                  | 146        | 168                  | 125        |
| Zero Count                           | 0              | 0                | 0                  | 16              | 0                  | 0               | 9              | 14                   | 37         | 15                   | 58         |
| 90% Flow (Days above)                | 865.4 (16)     | 677.3 (16)       | 22.23 (64)         | 26.92 (21)      | 2.32 (24)          | 28.62 (28)      | 389.68 (17)    | 42.29 (17)           | 35.91 (17) | 61.35 (19)           | 62.17 (42) |
| 75% Flow (Days above)                | 406.6 (29)     | 279.1 (27)       | 17.22 (68)         | 13.35 (38)      | 1.98 (82)          | 22.14 (41)      | 246.8 (47)     | 37.64 (51)           | 22.67 (48) | 28.73 (31)           | 16.58 (44) |
| 25% Flow (Days below)                | 39.6 (55)      | 51.1 (70)        | 11.89 (105)        | 3.04 (80)       | 1.60 (52)          | 4.42 (101)      | 16.9 (37)      | 15.6 (45)            | 2.6 (51)   | 6.78 (44)            | 0.61 (70)  |
| 10% Flow (Days below)                | 18.4 (31)      | 40.9 (47)        | 10.62 (101)        | 1.85 (64)       | 1.49 (47)          | 2.03 (97)       | 8.07 (28)      | 3.1 (27)             | 0.05 (40)  | 2.08 (23)            | 0.19 (64)  |
| Low Flow Stress Events               |                |                  |                    |                 |                    |                 |                |                      |            |                      |            |
| Julian Date of max                   | 161 (0.18)     | 179 (0.25)       | 186 (0.28)         | 177 (0.24)      | 148 (0.63)         | 211 (0.23)      | 193 (0.15)     | 213 (0.07)           | 142 (0.22) | 147 (0.00)           | 215 (0.16) |
| Flashiness                           | 0.23           | 0.18             | 0.64               | 0.71            | 0.22               | 0.29            | 0.24           | 0.06                 | 0.10       | 0.16                 | 0.17       |
| # of Fall Events (duration)          | 38 (-2.49)     | 33 (-2.85)       | 41 (-2.41)         | 31 (-1.93)      | 47 (-1.86)         | 32 (-2.35)      | 35 (-2.42)     | 29 (-2.02)           | 27 (-3.28) | 37 (-2.20)           | 15 (-3.36) |
| # of Rise Events (duration)          | 38 (2.28)      | 35 (2.31)        | 41 (1.67)          | 34 (2.33)       | 48 (1.68)          | 41 (1.99)       | 32 (2.27)      | 28 (1.86)            | 27 (2.05)  | 37 (1.73)            | 15 (2.16)  |
| # of signal day events               | 24             | 14               | 40                 | 29              | 53                 | 32              | 23             | 25                   | 13         | 35                   | 9          |

# RESULTS-Hydrology

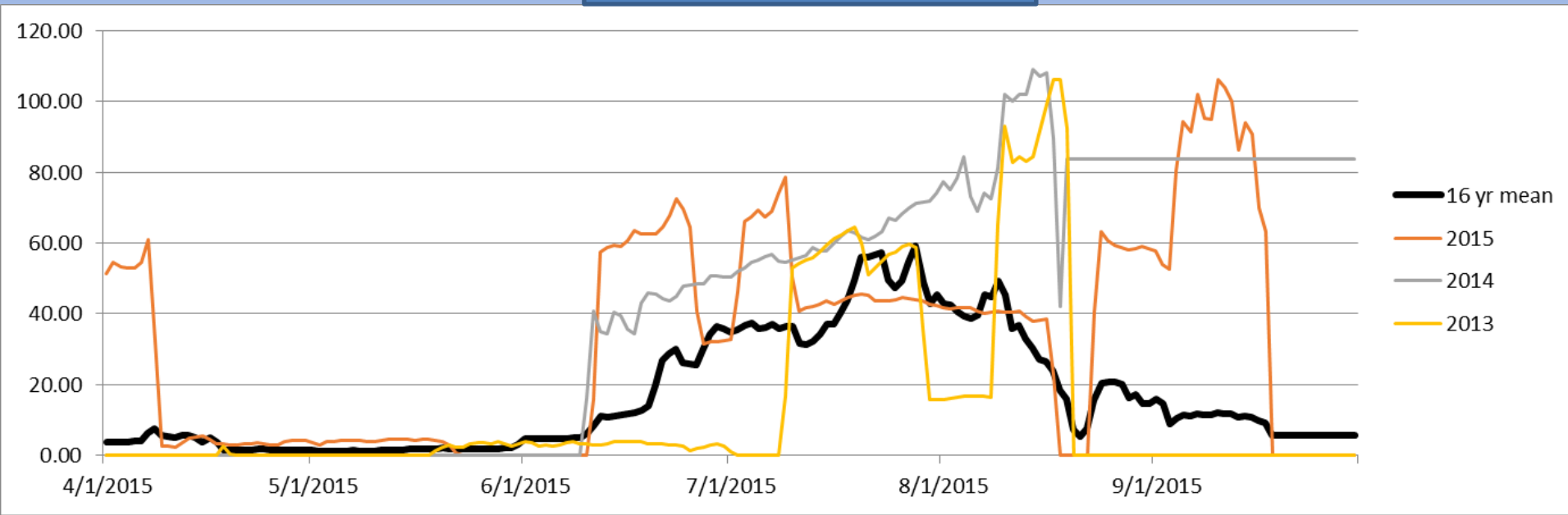
## Cache la Poudre—@ Fort Collins



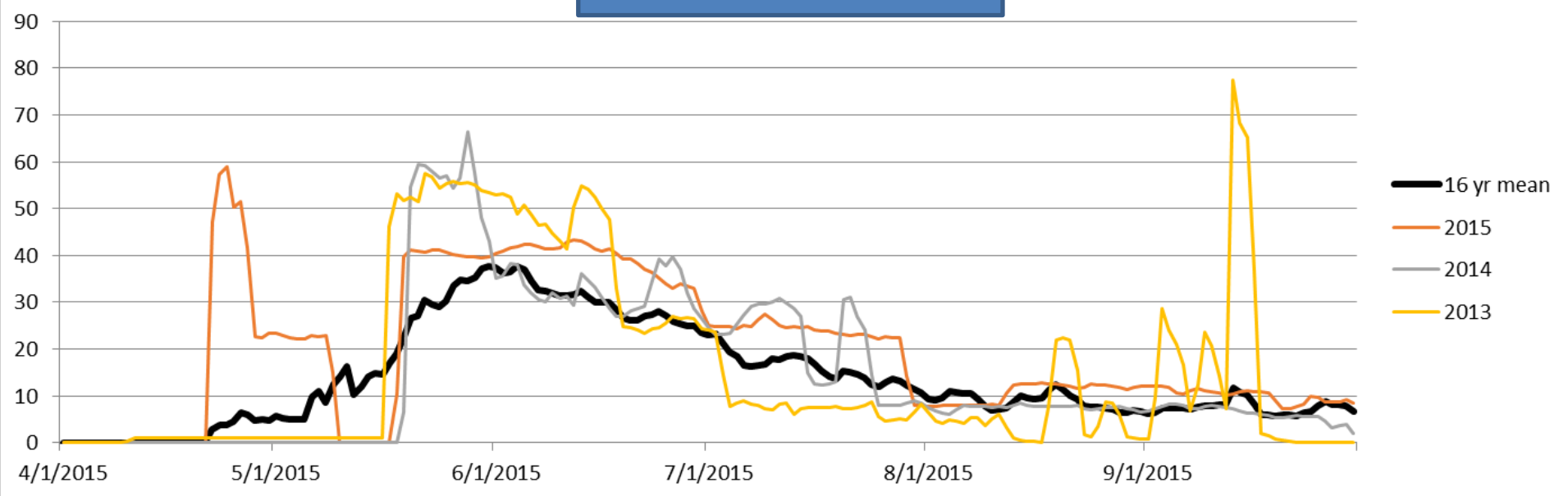
## Larimer and Weld –West Ditch



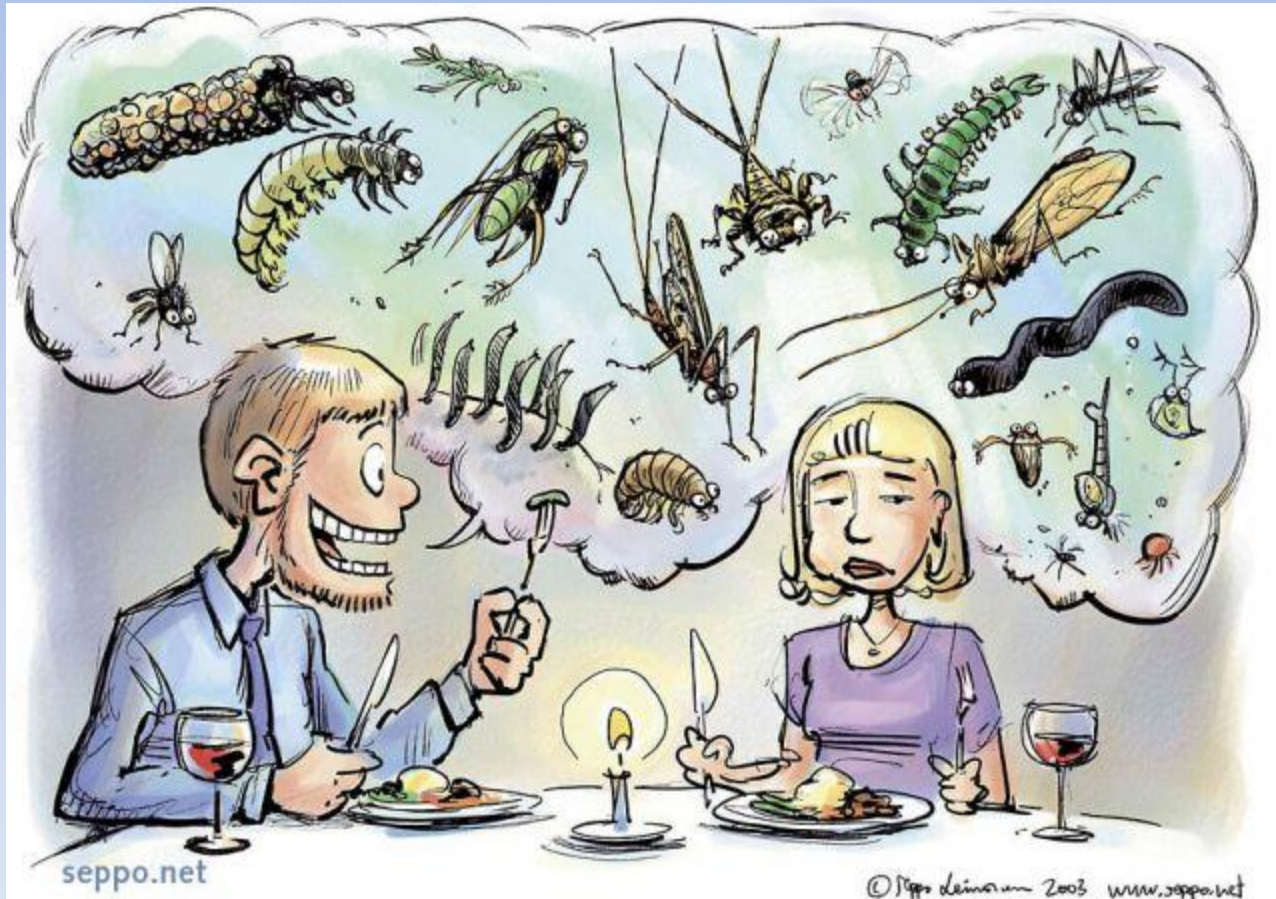
## New Mercer –West Ditch



## Larimer #2 –West Ditch



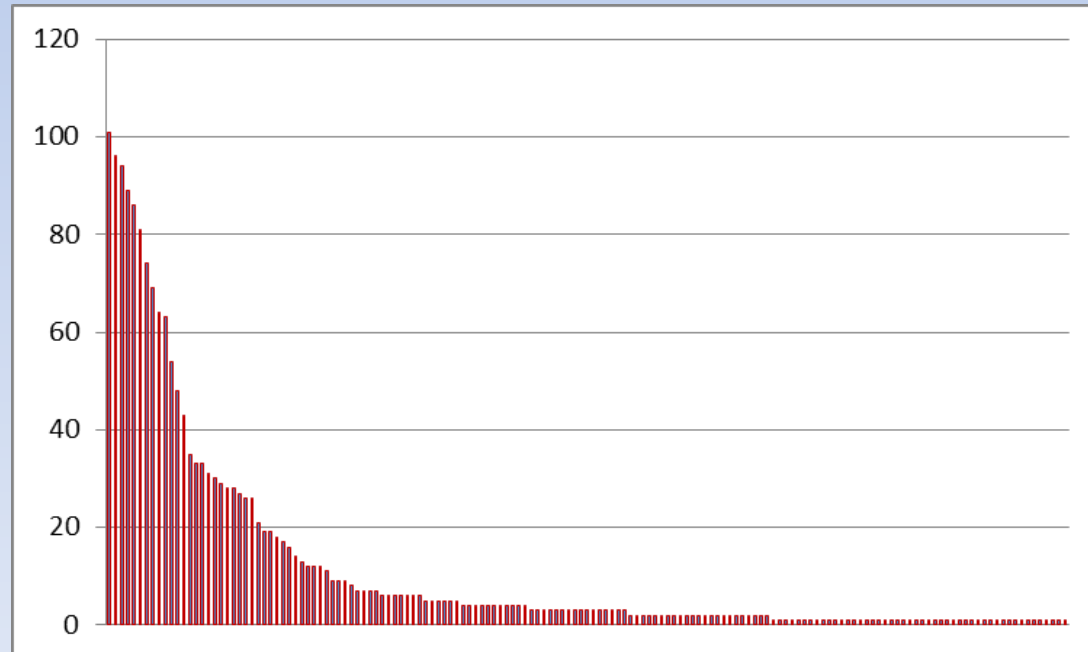
# Time for Aquatic Macro-invertebrates



# Diversity/Dominance

207 collection representing 40 sites over 3 years

- Most diverse – 1 canal site and 1 river site > 23 taxa
- Most common – 2 midges, 1 mayfly, 2 crustaceans
- All 6 major insect orders represented
- 48 observed once



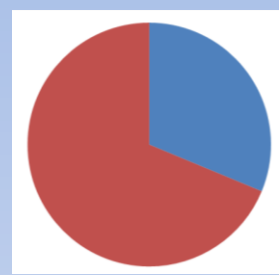
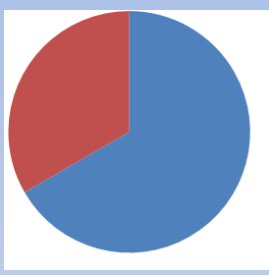


# Ephemeroptera, Plecoptera, Trichoptera

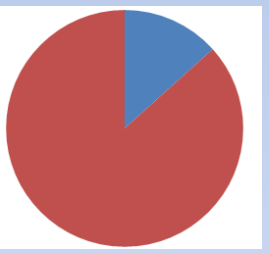
WEST

EAST

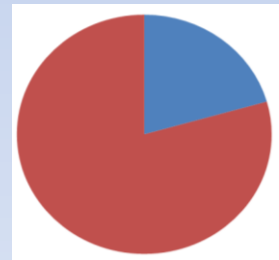
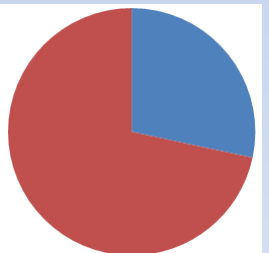
*Rivers*



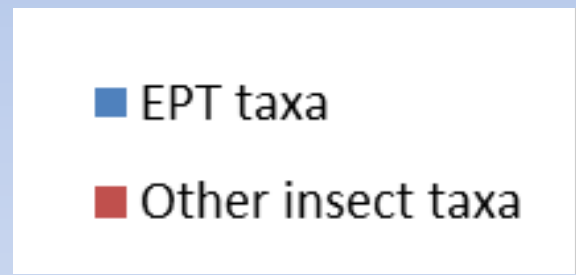
*Streams*



*Canals*



## Species Richness



*E*



*P*



*T*

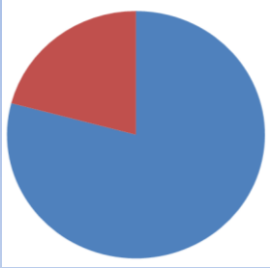
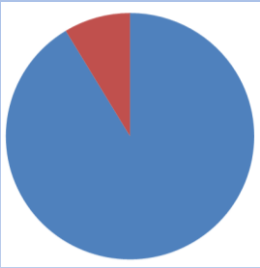


# Ephemeroptera, Plecoptera, Trichoptera

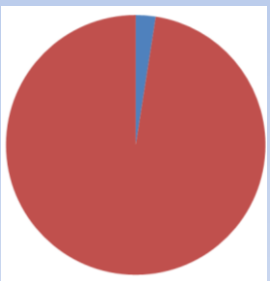
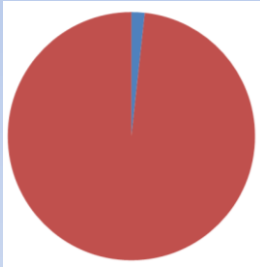
WEST

EAST

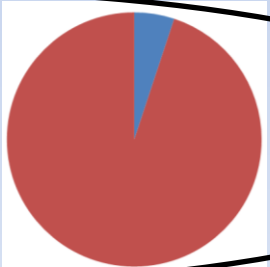
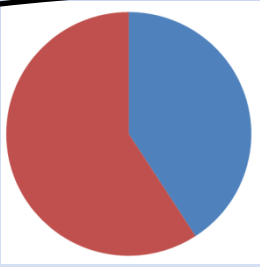
*Rivers*



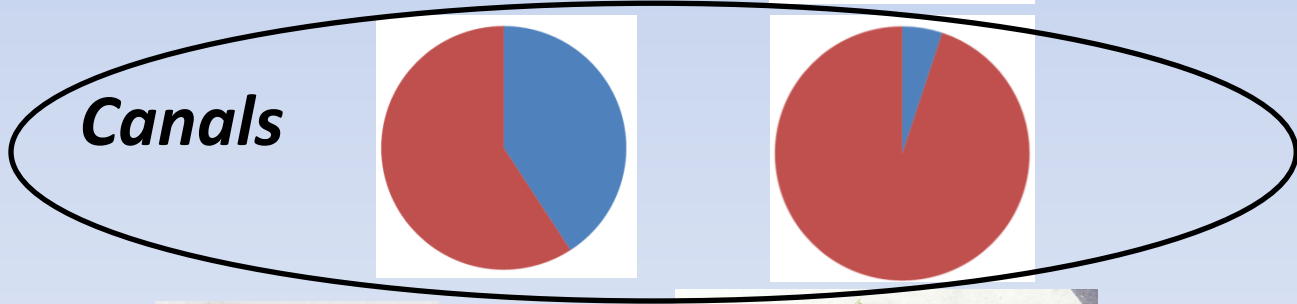
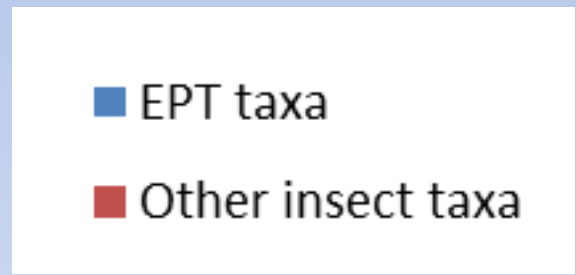
*Streams*



*Canals*



Abundance



*E*



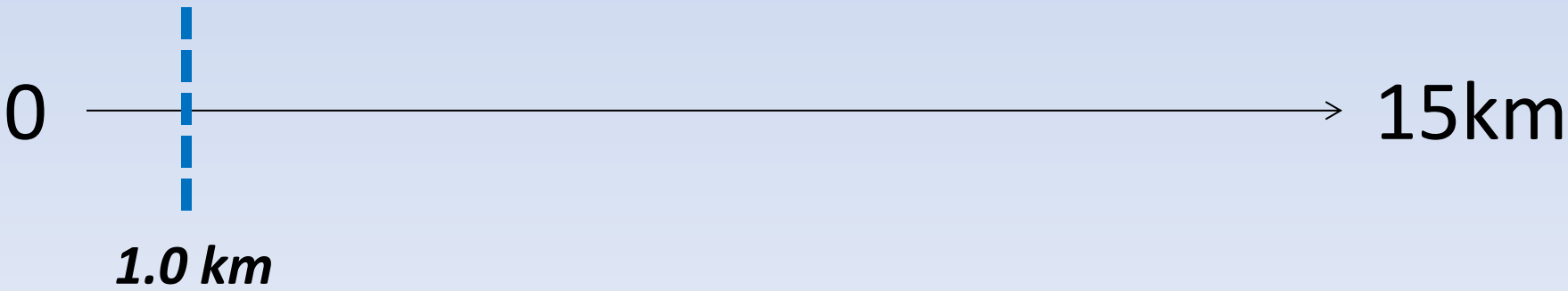
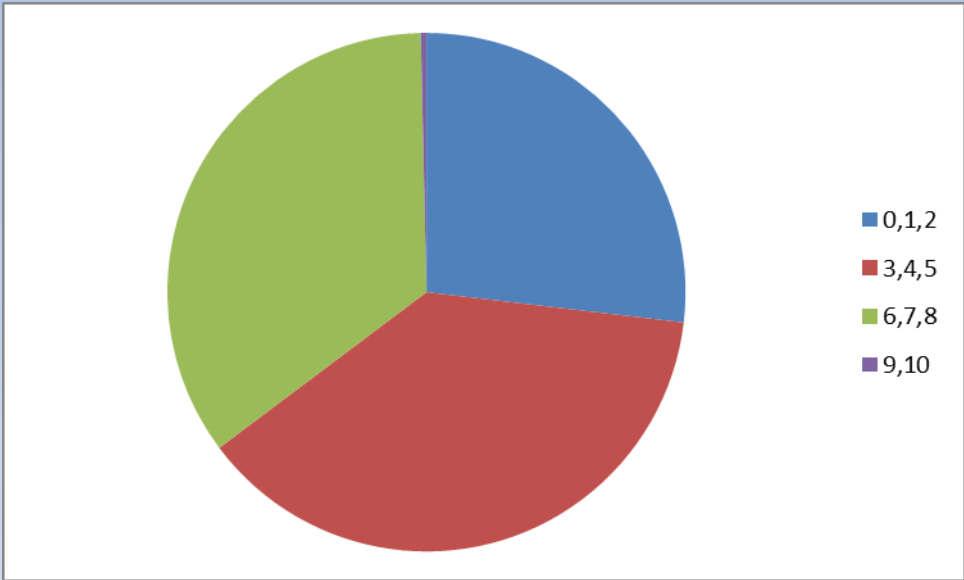
*P*



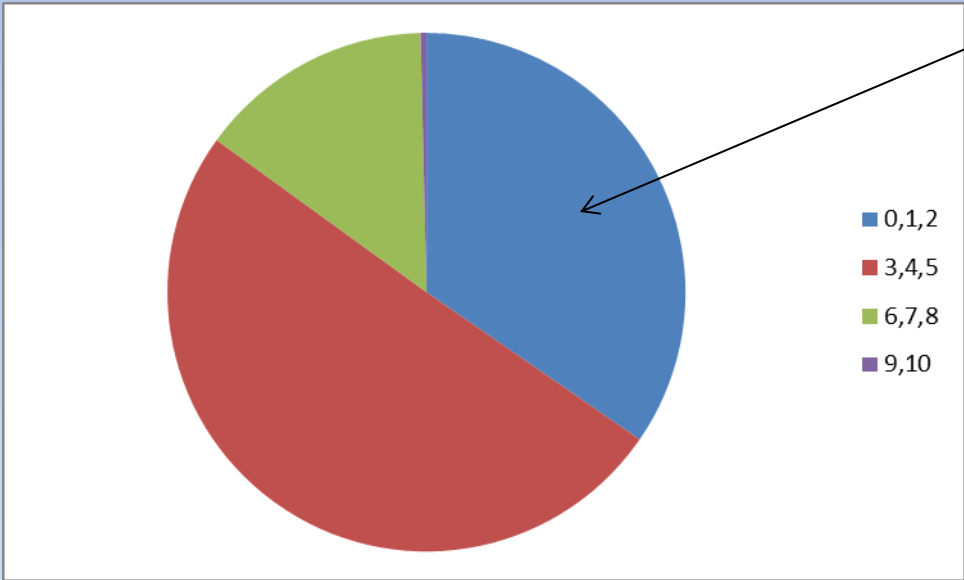
*T*



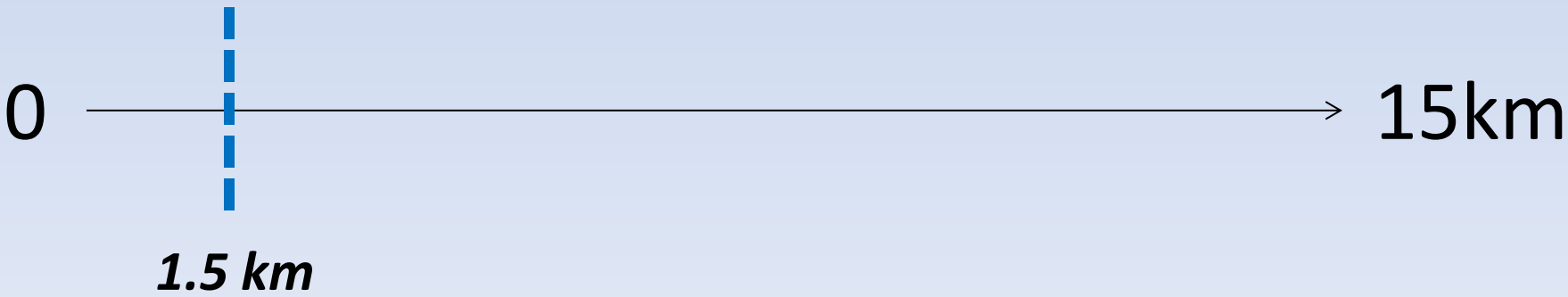
# Longitudinal Pattern of Aquatic insect tolerance



# Longitudinal Pattern of Aquatic insect tolerance

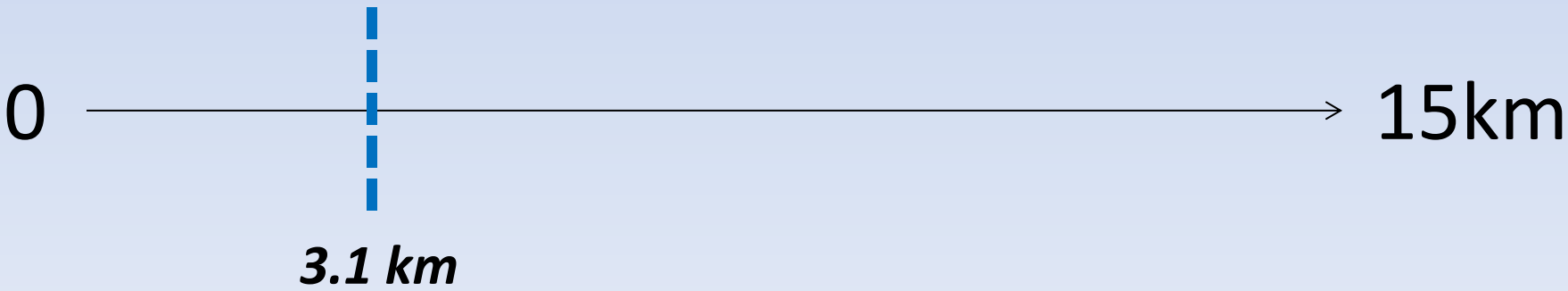
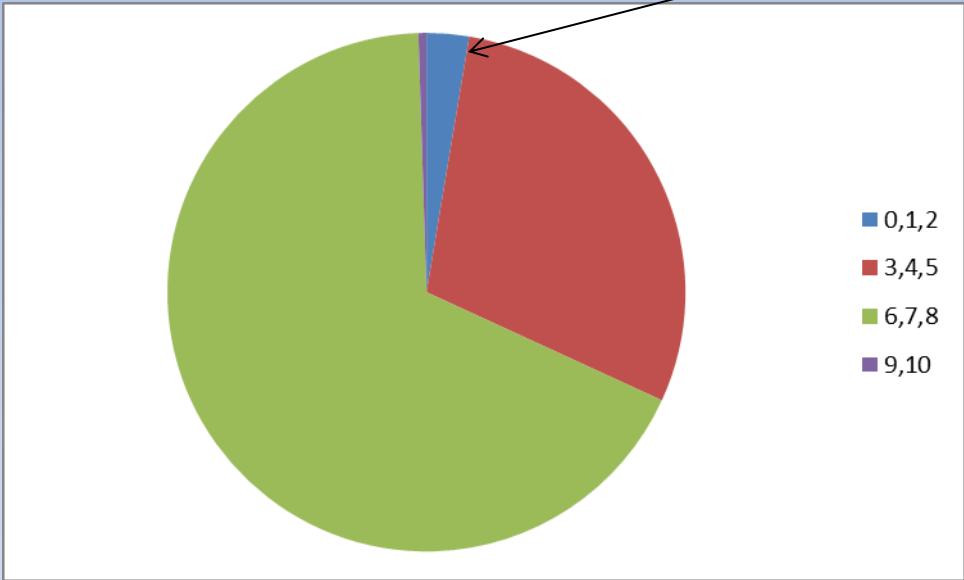


Still high proportion



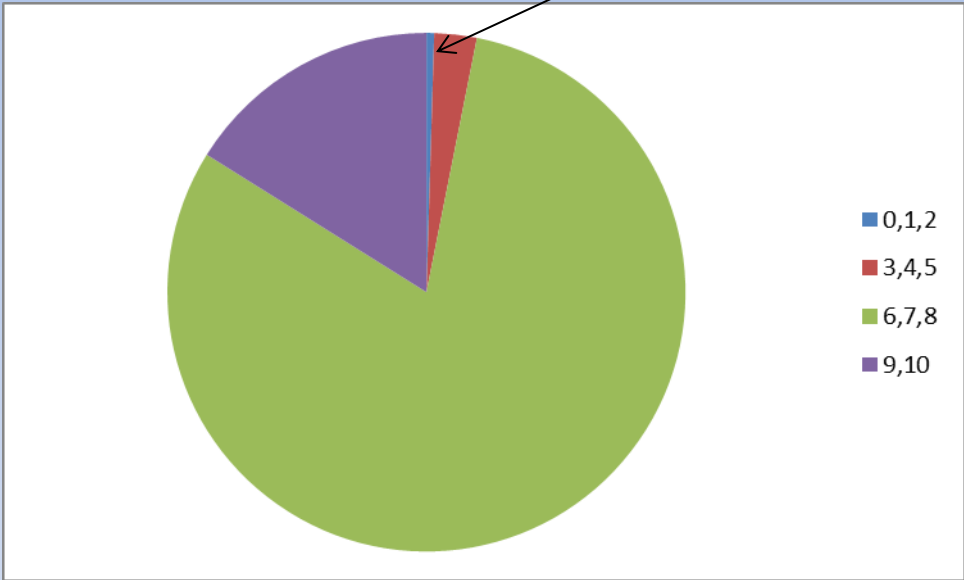
# Longitudinal Pattern of Aquatic insect tolerance

High quality taxa drop off

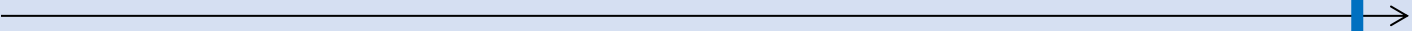


# Longitudinal Pattern of Aquatic insect tolerance

Where did they go?



0



15km



*14.9 km*

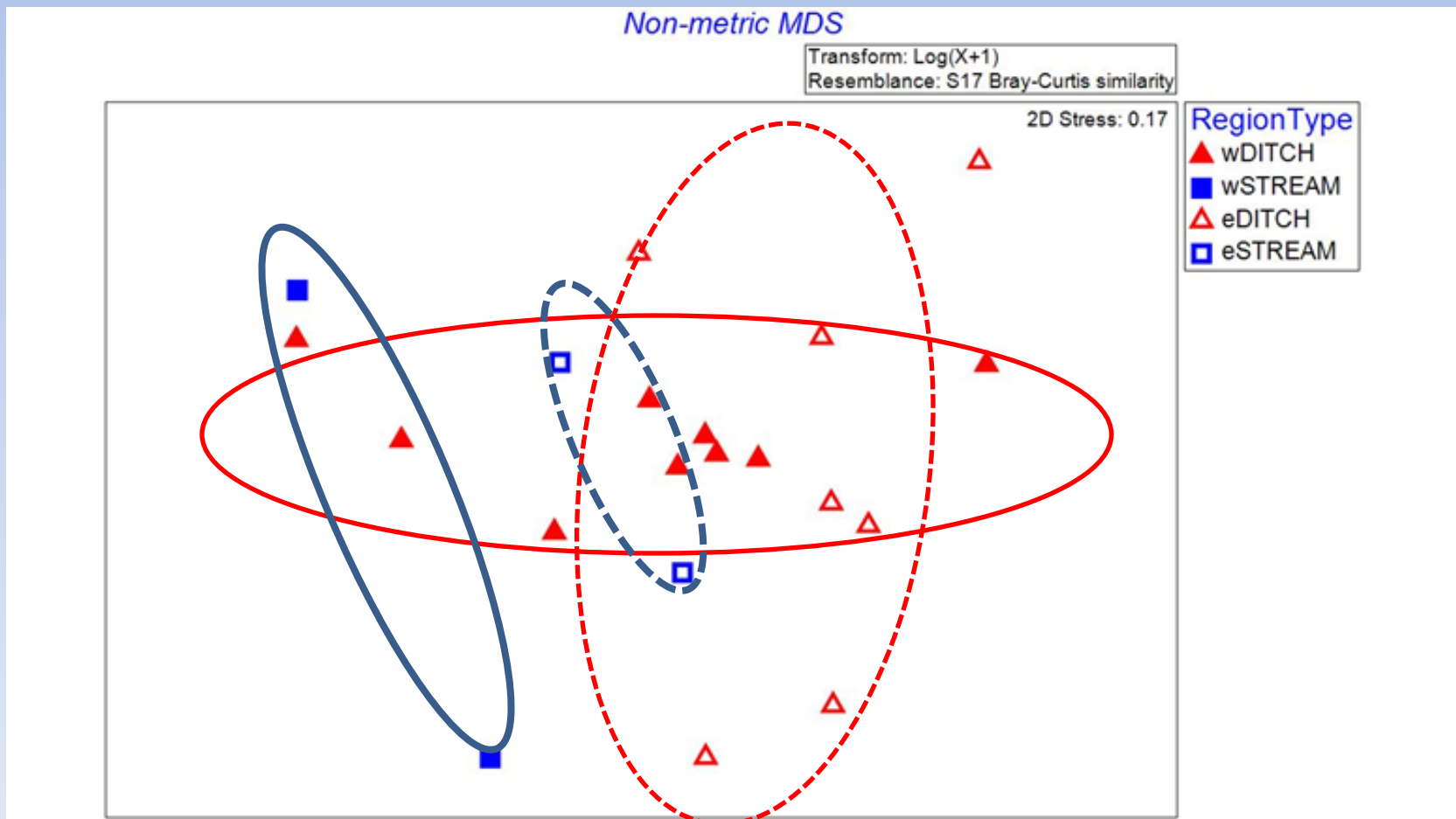
Using 2014/2015 data

**Ditches** and **Streams** are **different**

**Ditches** and **Streams** are **different** WITHIN a region

**Ditches** **different** BETWEEN regions

**Streams** **different** BETWEEN regions



# Time for Plants

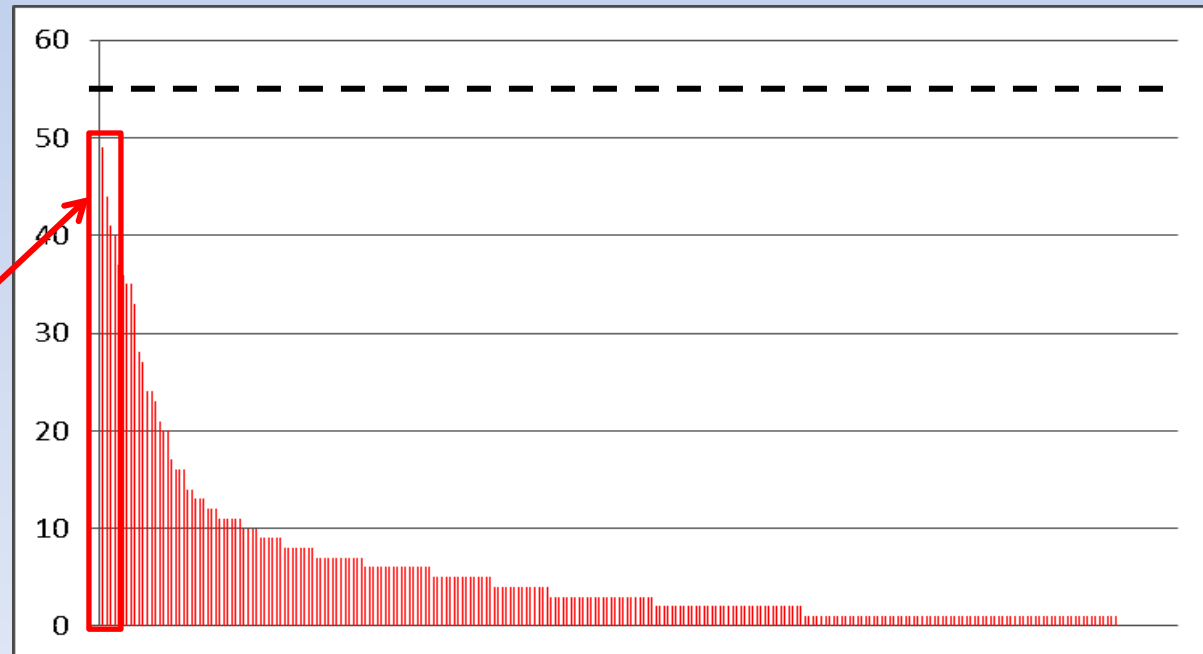




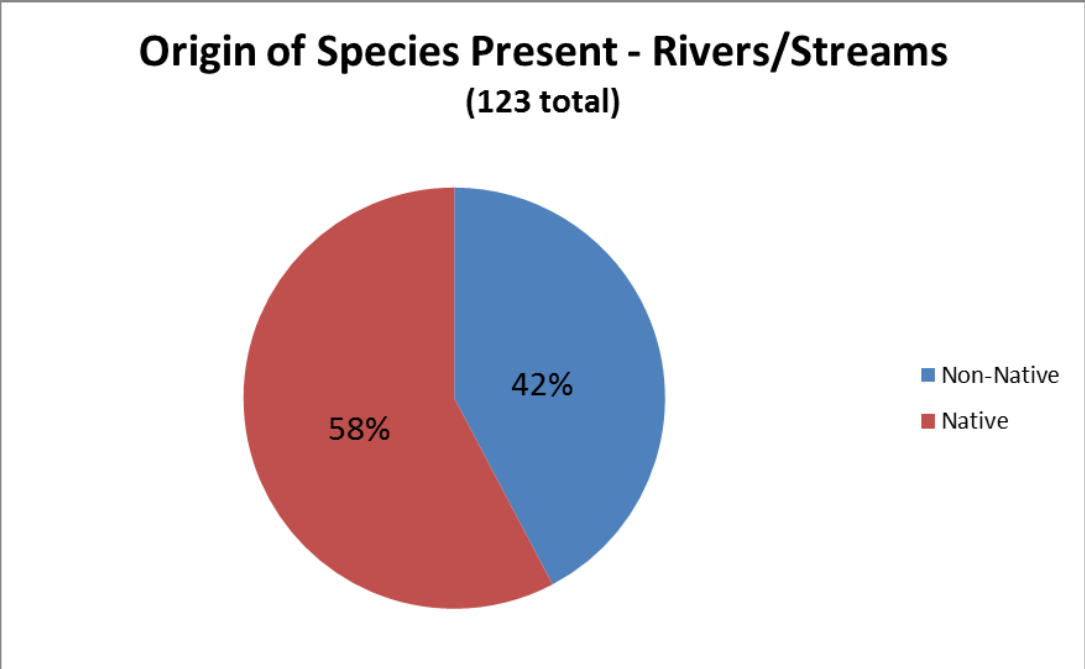
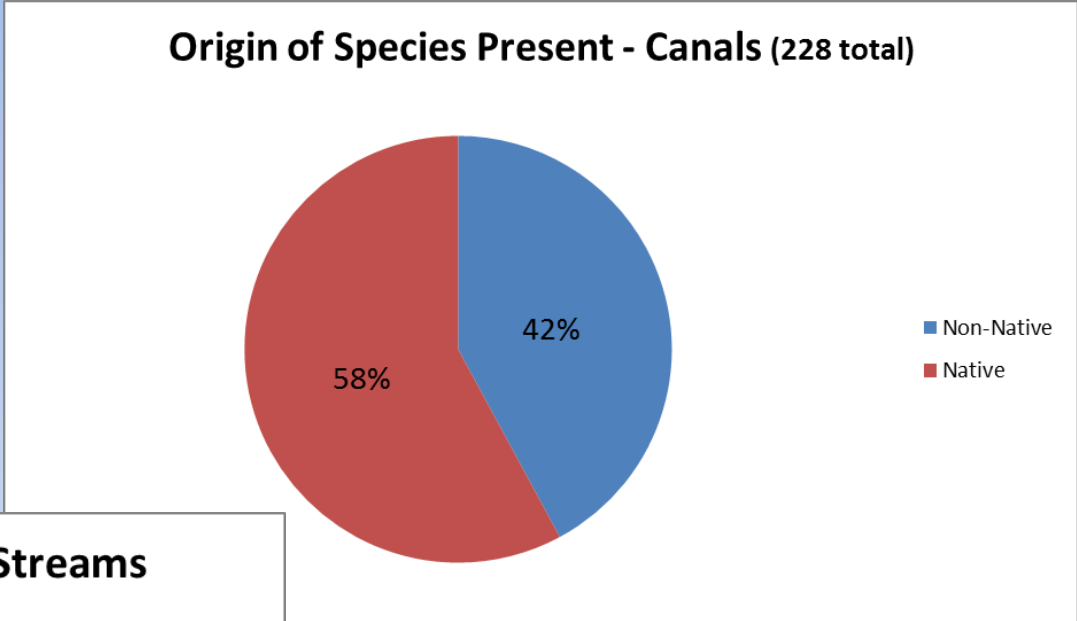
# Diversity/Dominance

- 249 species (58% native)
- *Bromus inermis* at 49 of 54 sites, in top 3 for all surfaces
- 78 species only at 1 site
- 22% annual

4 of the top 5 most abundant are non-native

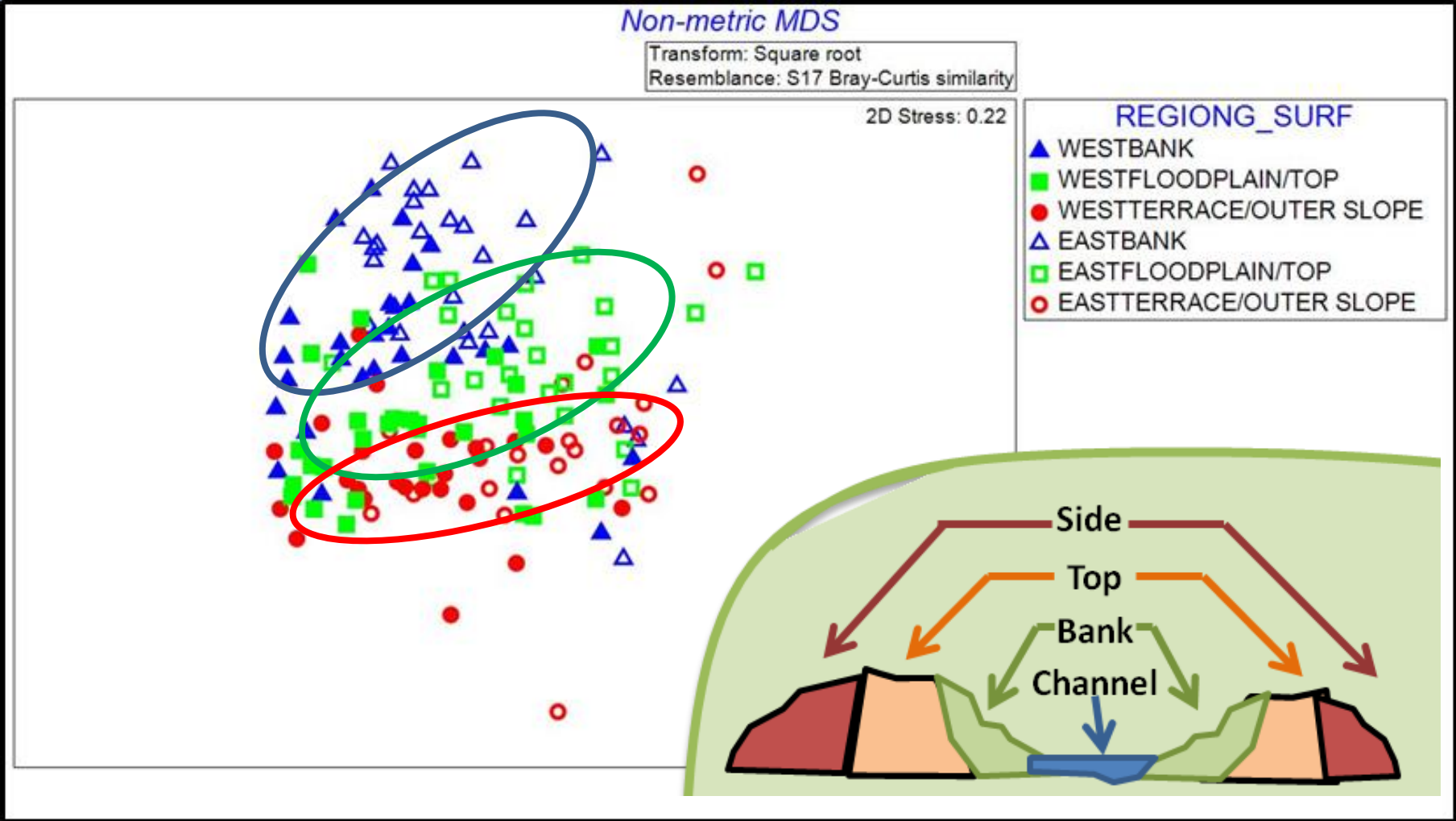


# Plant Origins



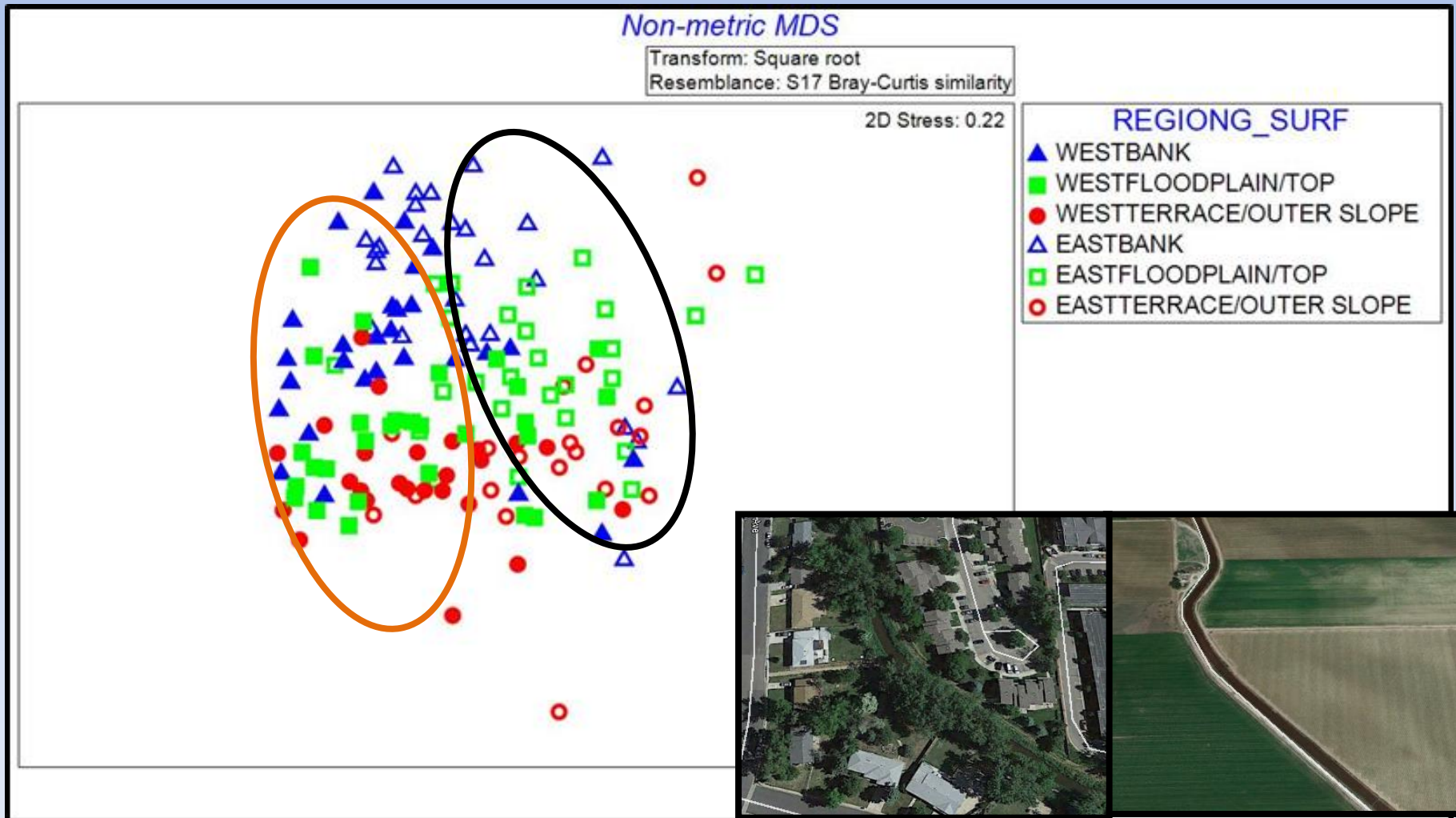
# Community Composition

Average cover for plots on each geomorphic surface

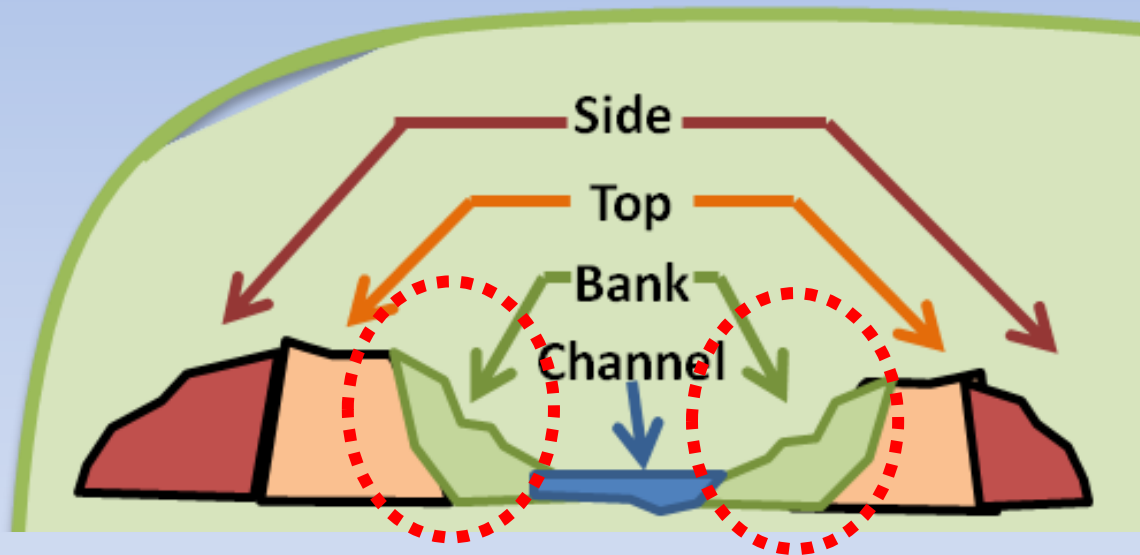


# Community Composition

Average cover for plots on each geomorphic surface



# Bank Surface



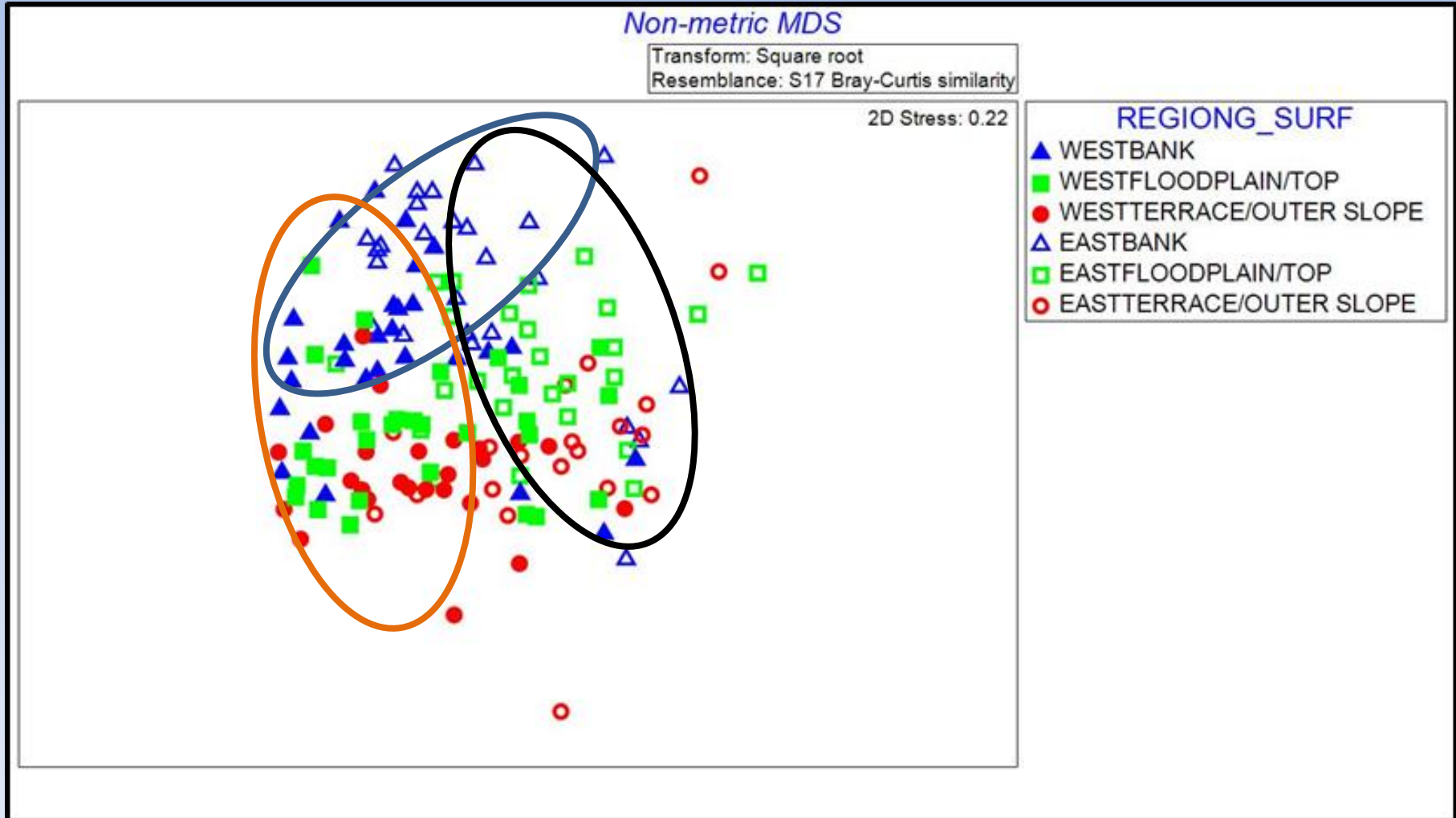
# Bank Surface

Using PERMANOVA F-test

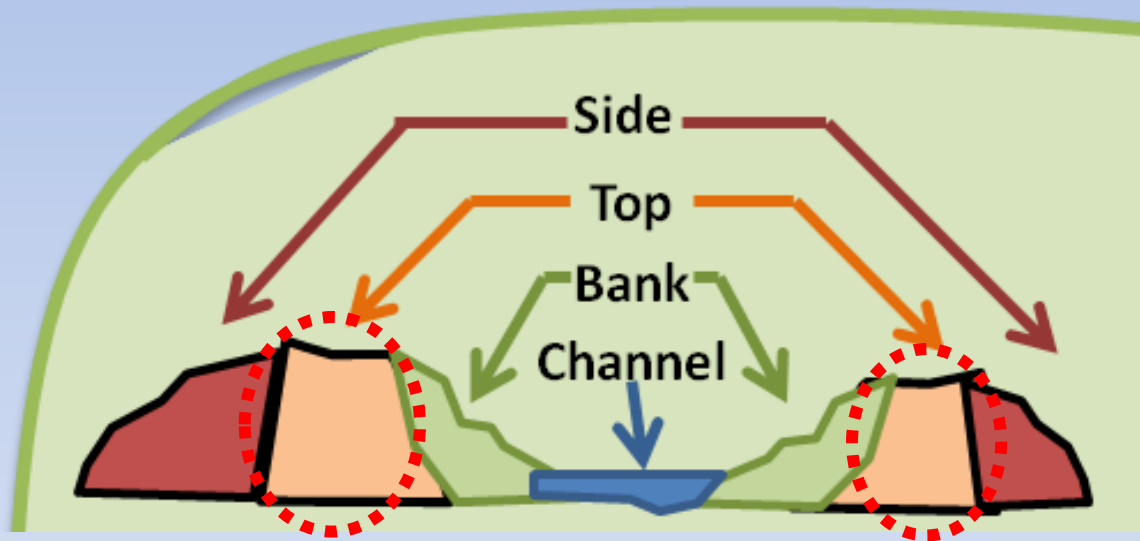
West **Ditches** NOT DIFFERENT from West **Streams**

East **Ditches** NOT DIFFERENT from East **Streams**

East **Ditches** different from West **Ditches**



# Top/Floodplain Surface



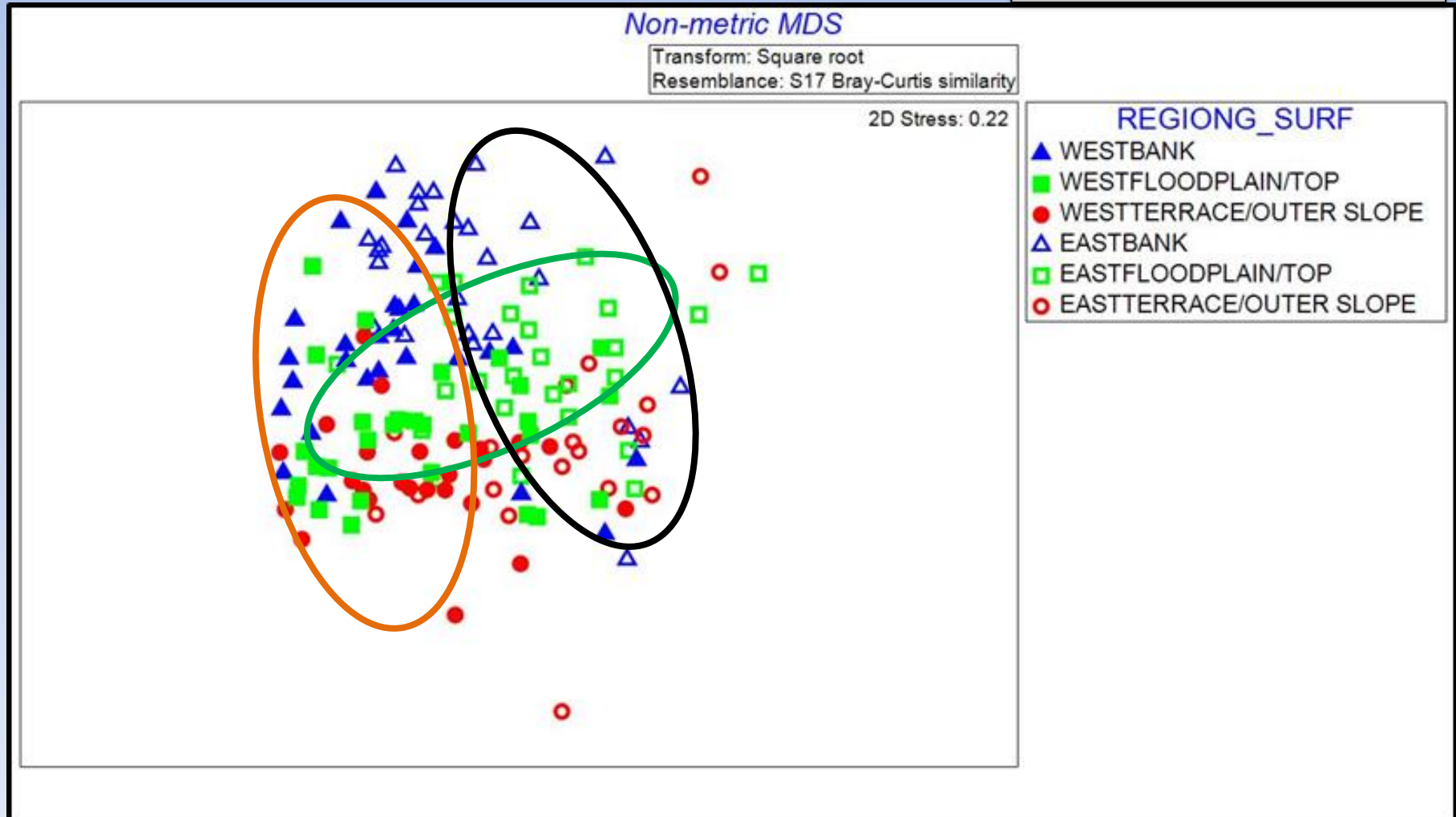
## Top/Floodplain Surface

West **Ditches** NOT DIFFERENT from West **Streams** (barely,  $F=1.3$ ,  $p=0.079$ )

East **Ditches** NOT DIFFERENT from East **Streams** (barely,  $F=1.29$ ,  $p=0.072$ )

East **Ditches** different from West **Ditches**

Using PERMANOVA F-test





# Major Questions

- Are ditches similar to streams?
  - For the plants?
  - For the aquatic invertebrates?
- Is there a regional component?
- Are there geomorphic components?

**YES**  
**NO**

**YES**  
**YES**

# Application – Habitat Suitability

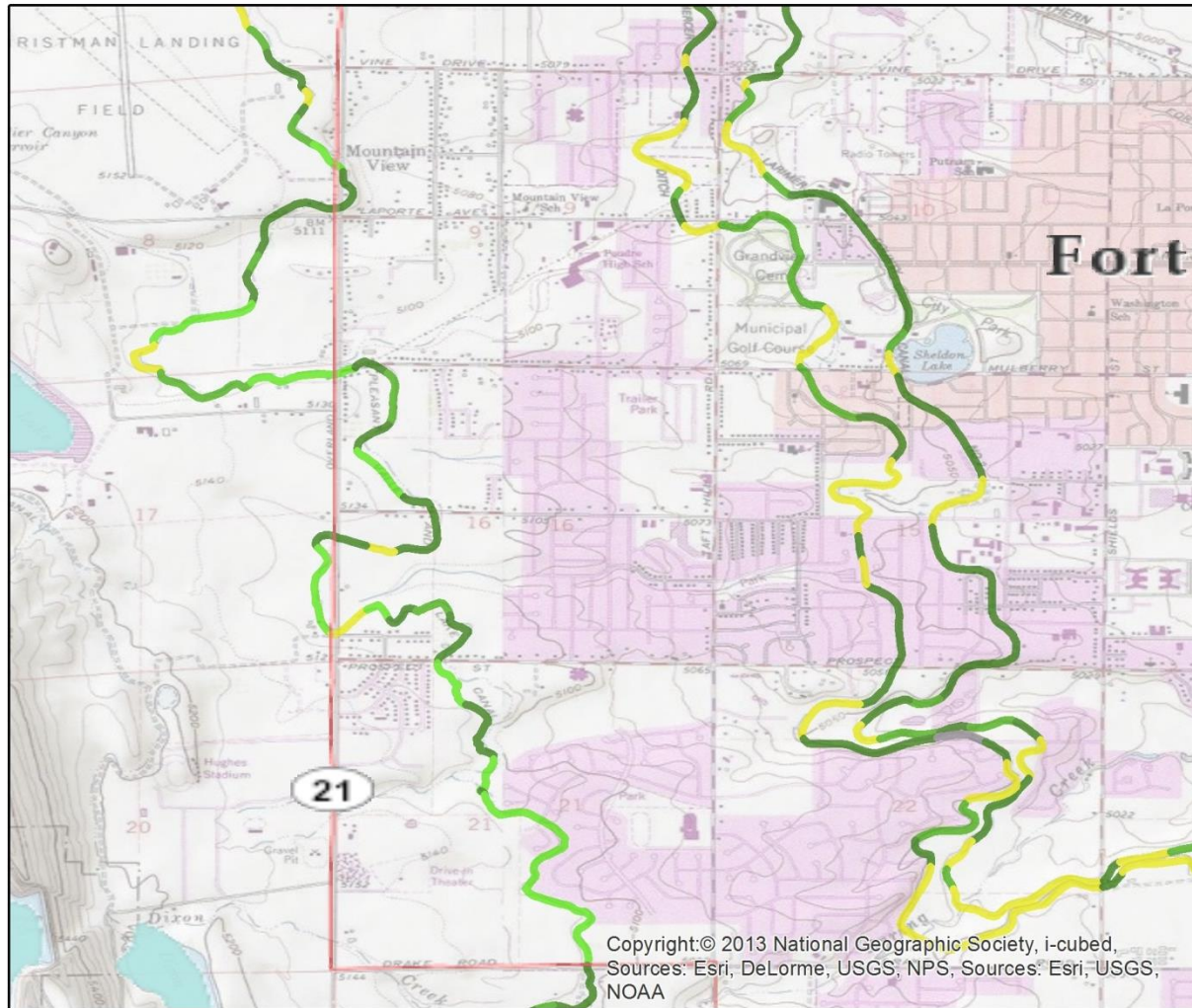
- Use the average and range of values of habitat attributes
  - (%grass, # berry producing plants, # strata)
  - (%tall canopy, %bare sediment)
- Query attributes specific to wildlife or plants

# Application Example – Leaping Mouse

- Riparian Habitat
  - Prefers mix of grasses, forbs and shrubs
  - Does not care about native
  - Dislikes bare areas (too many snakes)



# Application Example – Base Map



0 0.5 1 2  
Miles

# Application Example – Selection

The image shows a GIS application interface. On the left is the 'Select By Attributes' dialog box, and on the right is a data table window titled 'FortCollins\_Canals'.

**Select By Attributes Dialog:**

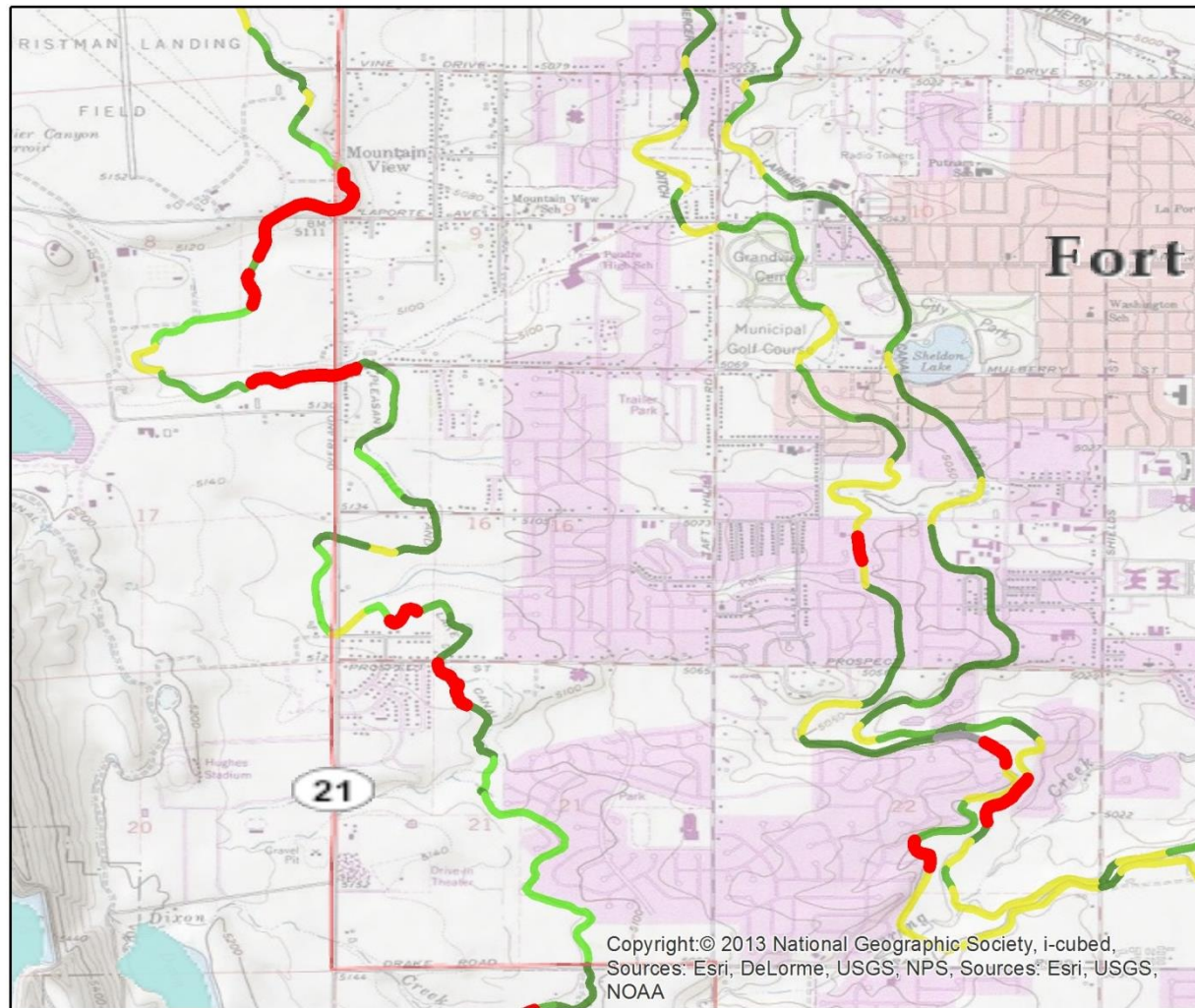
- Layer: FortCollins\_Canals
- Method: Create a new selection
- Attributes list: "Native", "Grass", "Forb", "Shrub", "Tree"
- SQL Expression: `"Grass" >15 AND "Shrub" >15 AND "Forb">15 AND "Bare" <15`

**FortCollins\_Canals Table:**

|  | Veg_Clas_1   | Uniq_ID_1 | cover_weig | Native | Grass | Forb  | Shrub | Tree  |
|--|--------------|-----------|------------|--------|-------|-------|-------|-------|
|  | Shrub        | 69        | 3.56       | 43.3   | 22.3  | 1.39  | 17.99 | 3.72  |
|  | Dense Canopy | 70        | 3.68       | 58.65  | 47.25 | 16.72 | 22.9  | 34.8  |
|  | Herb         | 71        | 2.97       | 59.77  | 56.43 | 14.21 | 3.71  | 0.22  |
|  | Dense Canopy | 72        | 2.46       | 39.04  | 20.25 | 8.27  | 13.64 | 61.35 |
|  | Shrub        | 73        | 3.05       | 61.43  | 46.77 | 18.98 | 18.6  | 36.62 |
|  | Herb         | 74        | 1.26       | 33.81  | 83.96 | 3.38  | 2.88  | 6.81  |
|  | Shrub        | 75        | 3.43       | 40.35  | 32.86 | 0.29  | 5.53  | 7.49  |
|  | Dense Canopy | 76        | 2.26       | 73.59  | 39.33 | 10.92 | 31.53 | 46.24 |
|  | Open Canopy  | 77        | 1.17       | 22.5   | 77.55 | 6.98  | 1.33  | 33.72 |
|  | Dense Canopy | 78        | 3.07       | 33.47  | 27.74 | 12    | 8.4   | 40.41 |
|  | Shrub        | 79        | 2.18       | 46.27  | 38.02 | 43.61 | 27.68 | 34.04 |
|  | Dense Canopy | 80        | 2.18       | 27.33  | 41.99 | 16.62 | 23.61 | 51.61 |
|  | Shrub        | 81        | 2.97       | 54.88  | 35.95 | 38.92 | 7.82  | 29.89 |
|  | Dense Canopy | 82        | 3.93       | 46.45  | 43.29 | 14.77 | 21.83 | 53.67 |
|  | Shrub        | 83        | 3.13       | 48.6   | 45.87 | 5.57  | 21.78 | 22.3  |
|  | Dense Canopy | 84        | 2.13       | 64.69  | 22.36 | 11.9  | 31.66 | 62.18 |

The table shows 24 rows selected, indicated by the status bar at the bottom: '(24 out of 261 Selected)'. The selected rows are those where the 'Native', 'Grass', and 'Forb' values are all greater than 15.

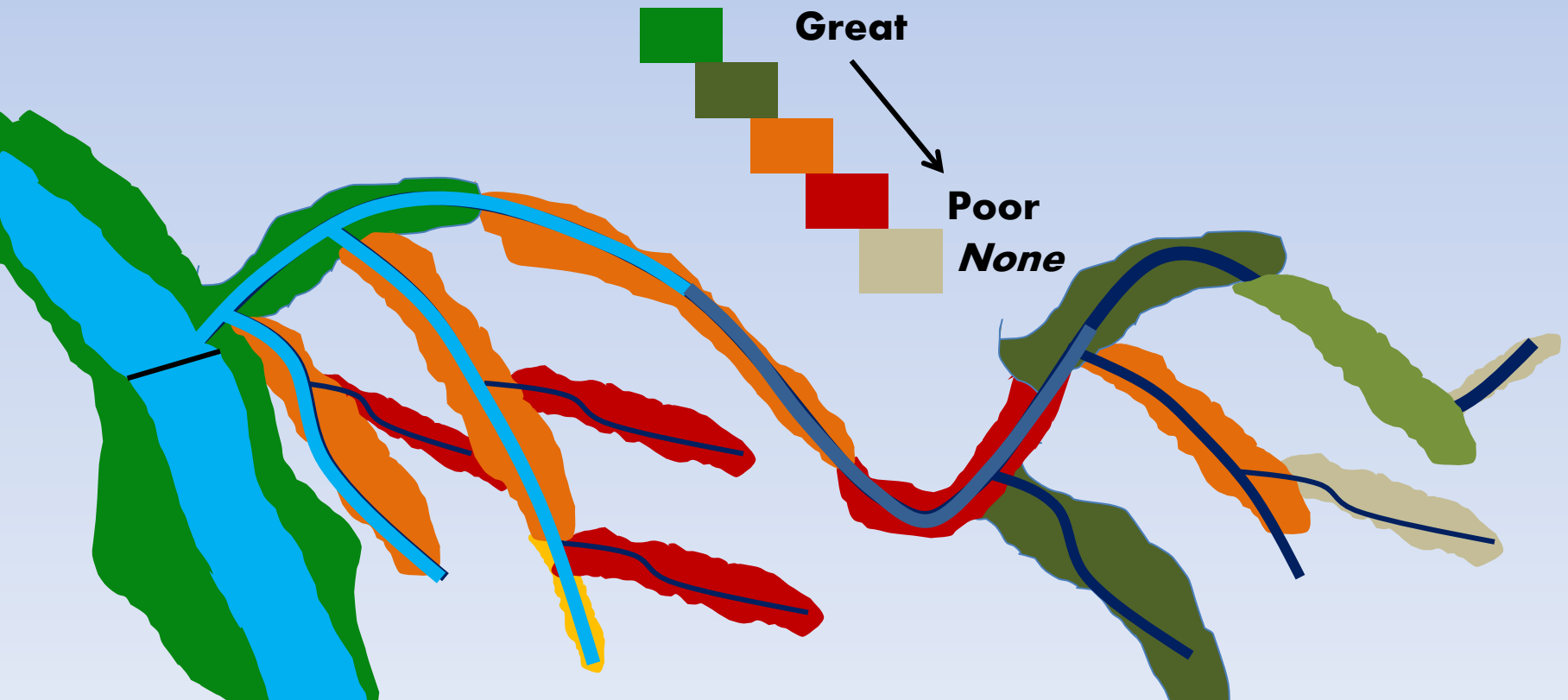
# Application Example – Suitable Areas



0 0.5 1 2 Miles

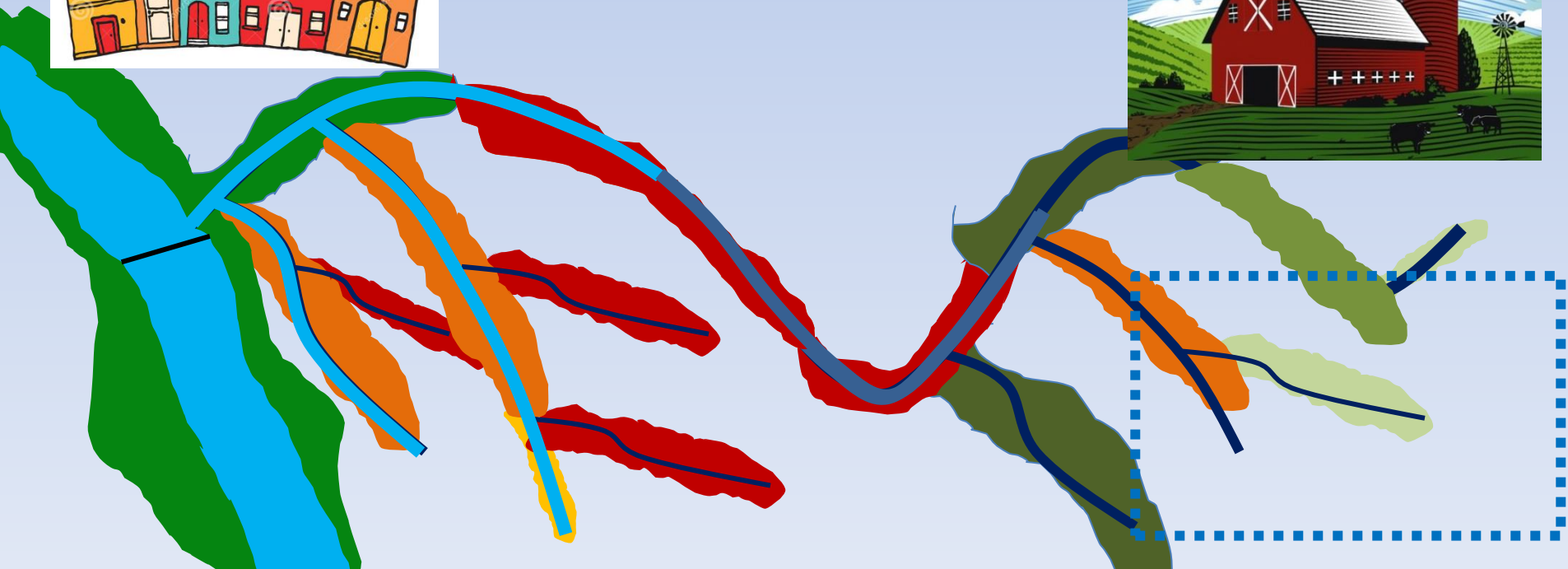
# Regional Application – Water Planning

- Categorize Ecological Value
  - Specific species, general habitat type and quality
- Risk analysis of changing water usage



# Regional Application – Water Planning

- Categorize Ecological Value
  - Specific species, general habitat type and quality
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# Easy Questions Please

**Thanks to :** Cooper, Kondratieff, Waskom & Merritt  
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**Irrigation Companies:** New Mercer, Larimer #2, Pleasant Valley and  
Lake, Larimer and Weld