Implementing Precision Conservation in the Susquehanna River Watershed

GIS Methods - Parcel Prioritization for Flow Path Buffer Installation

Contents

Abbreviations

AIT	Agriculture, Impervious, and Turf
DA	Drainage Area
EVHQ	Exceptional Value/High Quality
NHD	National Hydrography Dataset
ROA	Restoration Opportunity Area
PA DEP	Pennsylvania Department of Environmental Protection

Study Area

The prioritization described here was based on a previous prioritization of restoration opportunity areas in Centre and Clinton counties (http://envisionthesusquehanna.org/precision-conservation-data-and-tools/). This updated prioritization used a revised analysis conducted at the parcel scale, and expanded the geographic area to include Centre, Clinton, Huntingdon, and Lycoming counties.

Within the four county area, there are approximately 170,747 parcels. Of those, 6,286 parcels were identified as containing at least 0.4 acres of restoration opportunity areas and prioritized.

County	Parcels Prioritized
Centre	2,024
Clinton	772
Huntingdon	1,573
Lycoming	1,917
Four County Region	**6,286**

Foundational Datasets

High-resolution land cover

-The high-resolution land cover dataset was created by the Chesapeake Conservancy and partners using 2013 NAIP imagery to classify natural and human-made features on the landscape at one-meter resolution. Further details about how the land cover dataset was created and classes included can be found at: http://chesapeakeconservancy.org/conservation-innovation-center/high-resolution-data/land-cover-data-project/

Enhanced flow paths

- The enhanced flow path data was created using a Lidar-derived digital elevation model to identify concentrated flow paths and estimate channel width from flow accumulation. This product was combined with the high-resolution land cover data to create a comprehensive stream network. Further details on the methodology can be found at: http://envisionthesusquehanna.org/wp-content/uploads/2016/12/CC_New_Stream_Dataset_for_Susquehanna.pdf

Prioritization Datasets

Identification of restoration opportunity areas

We defined restoration opportunity areas (ROAs) as areas within a 35’ buffer (11 m) of the water network derived from the enhanced flow path analysis, that were classified as any of the following land cover categories:

- Wetlands
- Low vegetation
- Barren

We considered these land cover categories as “readily restorable/plantable,” excluding areas with existing vegetation (Tree canopy, Shrubland) and areas with existing infrastructure (Structures, Impervious surfaces, Impervious roads). We calculated area of each ROA in acres.

Filtering of ROAs

We erased any part of an ROA that intersected with road right of ways (data reference), as we considered these areas not “readily restorable/plantable.” We then filtered out ROAs that were less than 25 m^2. We cut ROAs by parcel boundaries and finally, we removed all ROAs located on parcels that contained less than 0.4 acres, based on feedback from implementation partners specifying 0.4 acres as a reasonable requisite potential project area for a property. After conducting ROA filtering, 6,286 parcels remained, containing a total of 72,371 ROAs.

Drainage areas to ROAs

We used the Watershed tool in Spatial Analyst to delineate drainage areas (DA) to each ROA. We calculated area of each DA in acres, and calculated the total land area within each drainage area classified as agriculture, impervious, or turf (AIT).

Stream condition datasets

We obtained impaired stream data from Pennsylvania Department of Environmental Protection (PA DEP), including the 2017 Integrated List of Non-Attaining (ILNA) streams and 2017 Total Maximum Daily Load (TMDL) streams. We also obtained 2017 Designated Use streams data from PA DEP.

We combined the ILNA and TMDL streams datasets to create comprehensive datasets of agriculturally impaired streams and non-agriculturally impaired streams. See Appendix for a list of select attributes in each dataset that we classified as agriculture vs. non-agricultural impairments. We used the designated use data to identify exceptional value/high quality (EVHQ) streams.

We selected ROAs within 30 meters of an agriculturally impaired stretch, non-agriculturally impaired stretch, or exceptional value/high quality (EVHQ) stretch. The 30-meter buffer was applied to account for lack of spatial overlap between the National Hydrography Dataset (NHD) on which the PA DEP impairment data is based, and the enhanced flow path analysis water network.

We also selected ROAs upstream of agriculturally-impaired or non-agriculturally impaired stretches. We used a manual process to snap the most downstream endpoint of each impaired tributary segment to the flow accumulation layer derived during the enhanced flow path analysis. Then we used the

Watershed tool to calculate drainage areas or catchments to those downstream points. Any gaps intersecting those catchments were selected and characterized as upstream of either agriculturally impaired or non-agriculturally impaired stretches.

Scoring and Prioritization Methodology

Attributes

We aggregated all attributes calculated for ROAs and DAs as described above to the parcel-scale. Each parcel was scored on the following attributes:

Abbreviation	Attribute	Rationale
ROA_Area	Total area of restoration opportunity areas on parcel (acres)	Indicates potential project area
Drain_Area	Total area of drainage areas to restoration opportunity areas on parcel (acres)	Land area draining to unbuffered area
AIT_DA	Sum of land areas classified as agriculture, impervious surfaces, or turf in drainage areas to restoration opportunity areas on parcel (acres)	Unbuffered runoff (nitrogen, phosphorus, sediment, chemicals) to water network
AIT_DA_ROA	Ratio of agriculture, impervious, and turf in drainage areas to restoration opportunities on parcel to the restoration opportunity areas on parcel (AIT_DA) / (ROA_Area)	Indication of cost effectiveness
Impaired Stretch	Parcel contains ROAs that are located: 0-not on an impaired stretch (ag or non-ag) 1- on a non-agriculturally impaired stretch 2-on an agriculturally impaired stretch	Need for water quality improvement
Exceptional value/high quality Stretch	Parcel contains ROAs that are located: 0-not on an EVHQ stretch 1-on an EVHQ stretch	Need for preservation of high quality streams
Impaired Proximity	Parcel contains ROAs that are located: 0-not upstream of ag or non-ag impaired stretches 1-upstream of only non-ag impaired stretches 2-upstream of ag-impaired stretches	Potential upstream impact on downstream impairments

Scoring

Gap Score

Each parcel's gap score was calculated by applying Equation 1, using values of three attribute values:

- Drainage Areas to ROAs on parcel [Drain_Area]
- Area of agriculture, impervious, and turf in drainage areas [AIT_DA]
- Ratio of (AIT in drainage areas) : (area of ROAs) [AIT_DA_ROA]

Equation 1.

(1.0 * AIT_DA) + (0.09 * Drain_Area) + (1.1 * AIT_DA_ROA)

Range of gap scores across the four county region: [0 – 1359]

Designation Score

Each parcels' designation score was assigned based on values of three attribute values:

- Impaired Stretch
- EVHQ Stretch
- Impaired Proximity

Parcel Description	**Impaired Stretch**	**EVHQ Stretch**	**Impaired Proximity**	**Designation Score**
No designations	0	0	0	0
Non-ag impaired proximity only	0	0	1	30
Non-ag impaired stretch and proximity	1	0	1	40
Ag-impaired proximity only	0	0	2	180
Non-ag impaired stretch, ag-impaired proximity	1	0	2	180
Ag-impaired stretch and proximity	2	0	2	240
EVHQ only	0	1	0	60
Non-ag impaired proximity + EVHQ	0	1	1	90
Non-ag impaired stretch, non-ag impaired proximity + EVHQ	1	1	1	100
Ag impaired proximity + EVHQ	0	1	2	280
Non-ag impaired stretch, ag-impaired proximity + EVHQ	1	1	2	280
Ag-impaired stretch, Ag-impaired proximity, + EVHQ	2	1	2	540

Range of designation scores across the four county region: [0 – 540]

Total Score

Each parcel's total score was calculated by adding the gap score and designation score.

Ranking and Tiers for Prioritization

Based on each parcel's total score, each was assigned a rank and tier (1-5) for the four county region (parcel ranked against all other parcels in the four counties) and a rank and tier (1-5) for the individual county (parcel ranked against only other parcels in the same county).

Table x. possible ranges of ranks by the four county region and by county.

County	Rank Range
Four County Region	[1 - 6,286]
Centre	[1 - 2,024]
Clinton	[1 - 772]
Huntingdon	[1 - 1,573]
Lycoming	[1 - 1,917]

We generated tiers in R statistical software using natural breaks (Jenks method) based on the distribution of final scores for both the four county region and for each county. See appendix for specific breaks and graphs of data distributions.

Table x. Summary of parcel tier distributions by the four county region and by county

Tier	All 4 Counties	Lycoming	Huntingdon	Clinton	Centre
1	278	36	71	28	169
2	534	161	142	72	253
3	1044	346	262	142	419
4	1904	676	559	238	532
5	2526	698	539	292	651
Sum	6286	1917	1573	772	2024
Tier 1 and 2	812	197	213	100	422

Appendices

Insert GIS model images.

Table x. ILNA streams data, attributes considered to be agricultural impairments highlighted in orange.

Primary Cause of Impairment
Abandoned Mine Drainage - Cause Unknown
Abandoned Mine Drainage - Flow Alterations
Abandoned Mine Drainage - Metals
Abandoned Mine Drainage - Other Habitat Alterations
Abandoned Mine Drainage - Other Inorganics (Sulfates, etc.)
Abandoned Mine Drainage - pH
Abandoned Mine Drainage - Siltation
Abandoned Mine Drainage - Suspended Solids
Abandoned Mine Drainage - TDS
Abandoned Mine Drainage - Unknown Toxicity
Abandoned Mine Drainage - Water/Flow Variability
Agriculture - Cause Unknown
Agriculture - DO/BOD
Agriculture - Excessive Algal Growth
Agriculture - Filling and Draining
Agriculture - Flow Alterations
Agriculture - Nutrients
Agriculture - Organic Enrichment/Low D.O.
Agriculture - Other Habitat Alterations
Agriculture - Pathogens
Agriculture - pH
Agriculture - Priority Organics
Agriculture - Siltation
Agriculture - Suspended Solids
Agriculture - TDS
Agriculture - Turbidity
Agriculture - Unknown Toxicity
Agriculture - Water/Flow Variability
Animal Feeding Agric - Nutrients
Animal Feeding Agric - Organic Enrichment/Low D.O.
Atmospheric Deposition - Mercury
Atmospheric Deposition - Metals
Atmospheric Deposition - pH
Bank Modifications - Other Habitat Alterations
Bank Modifications - Siltation
Bank Modifications - Thermal Modifications

Channelization - Flow Alterations
Channelization - Other Habitat Alterations
Channelization - Siltation
Channelization - Thermal Modifications
Channelization - Water/Flow Variability
Combined Sewer Overflow - DO/BOD
Combined Sewer Overflow - Metals
Combined Sewer Overflow - Nonpriority Organics
Combined Sewer Overflow - Nutrients
Combined Sewer Overflow - Organic Enrichment/Low D.O.
Combined Sewer Overflow - Suspended Solids
Combined Sewer Overflow - Water/Flow Variability
Construction - Other Habitat Alterations
Construction - Siltation
Crop Related Agric - Excessive Algal Growth
Crop Related Agric - Flow Alterations
Crop Related Agric - Nutrients
Crop Related Agric - Organic Enrichment/Low D.O.
Crop Related Agric - Siltation
Crop Related Agric - Turbidity
Crop Related Agric - Unknown Toxicity
Draining or Filling - Filling and Draining
Draining or Filling - Siltation
Erosion from Derelict Land - Siltation
Flow Regulation/Modification - Flow Alterations
Flow Regulation/Modification - Siltation
Flow Regulation/Modification - Thermal Modifications
Flow Regulation/Modification - Water/Flow Variability
Golf Courses - Nutrients
Golf Courses - Other Habitat Alterations
Golf Courses - Pesticides
Golf Courses - Siltation
Golf Courses - Water/Flow Variability
Grazing Related Agric - Nutrients
Grazing Related Agric - Organic Enrichment/Low D.O.
Grazing Related Agric - Siltation
Habitat Modification - Flow Alterations
Habitat Modification - Nutrients
Habitat Modification - Organic Enrichment/Low D.O.
Habitat Modification - Other Habitat Alterations
Habitat Modification - Siltation
Habitat Modification - Turbidity
Highway, Road, Bridge Const. - Metals

Highway, Road, Bridge Const. - Siltation
Hydromodification - Filling and Draining
Hydromodification - Flow Alterations
Hydromodification - Nutrients
Hydromodification - Other Habitat Alterations
Hydromodification - Siltation
Hydromodification - Water/Flow Variability
Industrial Point Source - Cause Unknown
Industrial Point Source - Chlorides
Industrial Point Source - Metals
Industrial Point Source - Nutrients
Industrial Point Source - Organic Enrichment/Low D.O.
Industrial Point Source - Other Habitat Alterations
Industrial Point Source - PCB
Industrial Point Source - Priority Organics
Industrial Point Source - Siltation
Industrial Point Source - Suspended Solids
Industrial Point Source - TDS
Industrial Point Source - Thermal Modifications
Industrial Point Source - Unknown Toxicity
Land Development - Cause Unknown
Land Development - Flow Alterations
Land Development - Nutrients
Land Development - Other Habitat Alterations
Land Development - Siltation
Land Development - Water/Flow Variability
Land Disposal - Cause Unknown
Land Disposal - Priority Organics
Land Disposal - Siltation
Municipal Point Source - Cause Unknown
Municipal Point Source - Chlorine
Municipal Point Source - Nutrients
Municipal Point Source - Organic Enrichment/Low D.O.
Municipal Point Source - Pathogens
Municipal Point Source - Siltation
Municipal Point Source - Suspended Solids
Municipal Point Source - TDS
Municipal Point Source - Un-ionized Ammonia
Municipal Point Source - Water/Flow Variability
Natural Sources - Cause Unknown
Natural Sources - Metals
Natural Sources - Nutrients
Natural Sources - Organic Enrichment/Low D.O.

Natural Sources - pH
Natural Sources - Siltation
Natural Sources - Water/Flow Variability
On site Wastewater - Excessive Algal Growth
On site Wastewater - Metals
On site Wastewater - Nutrients
On site Wastewater - Organic Enrichment/Low D.O.
On site Wastewater - Pathogens
On site Wastewater - Siltation
On site Wastewater - Unknown Toxicity
Other - Cause Unknown
Other - Metals
Other - Nutrients
Other - Organic Enrichment/Low D.O.
Other - Other Habitat Alterations
Other - Pathogens
Other - pH
Other - Siltation
Other - TDS
Other - Water/Flow Variability
Package Plants - Nutrients
Package Plants - Organic Enrichment/Low D.O.
Package Plants - Suspended Solids
Package Plants - Un-ionized Ammonia
Petroleum Activities - Metals
Petroleum Activities - Nonpriority Organics
Petroleum Activities - Oil and Grease
Petroleum Activities - pH
Petroleum Activities - Siltation
Recreation and Tourism - Cause Unknown
Recreation and Tourism - Siltation
Removal of Vegetation - Cause Unknown
Removal of Vegetation - Nutrients
Removal of Vegetation - Other Habitat Alterations
Removal of Vegetation - Siltation
Removal of Vegetation - Water/Flow Variability
Road Runoff - Cause Unknown
Road Runoff - Flow Alterations
Road Runoff - Nutrients
Road Runoff - Oil and Grease
Road Runoff - Other Habitat Alterations
Road Runoff - Siltation
Road Runoff - Water/Flow Variability

Silvaculture - Metals
Silvaculture - Siltation
Small Residential Runoff - Cause Unknown
Small Residential Runoff - Flow Alterations
Small Residential Runoff - Nutrients
Small Residential Runoff - Organic Enrichment/Low D.O.
Small Residential Runoff - Other Habitat Alterations
Small Residential Runoff - Siltation
Small Residential Runoff - Water/Flow Variability
Source Unknown - Cause Unknown
Source Unknown - Exotic Species
Source Unknown - Mercury
Source Unknown - Metals
Source Unknown - Nutrients
Source Unknown - Organic Enrichment/Low D.O.
Source Unknown - Osmotic Pressure
Source Unknown - Other Inorganics (Sulfates, etc.)
Source Unknown - Pathogens
Source Unknown - PCB
Source Unknown - Siltation
Source Unknown - TDS
Source Unknown - Unknown Toxicity
Subsurface Mining - Exotic Species
Subsurface Mining - Metals
Subsurface Mining - Osmotic Pressure
Subsurface Mining - pH
Subsurface Mining - Siltation
Subsurface Mining - TDS
Surface Mining - Flow Alterations
Surface Mining - Metals
Surface Mining - Other Habitat Alterations
Surface Mining - Siltation
Surface Mining - TDS
Surface Mining - Water/Flow Variability
Upstream Impoundment - Cause Unknown
Upstream Impoundment - Excessive Algal Growth
Upstream Impoundment - Flow Alterations
Upstream Impoundment - Metals
Upstream Impoundment - Nutrients
Upstream Impoundment - Organic Enrichment/Low D.O.
Upstream Impoundment - Other Habitat Alterations
Upstream Impoundment - Siltation
Upstream Impoundment - Water/Flow Variability

Urban Runoff/Storm Sewers - Cause Unknown
Urban Runoff/Storm Sewers - Flow Alterations
Urban Runoff/Storm Sewers - Metals
Urban Runoff/Storm Sewers - Nutrients
Urban Runoff/Storm Sewers - Oil and Grease
Urban Runoff/Storm Sewers - Organic Enrichment/Low D.O.
Urban Runoff/Storm Sewers - Other Habitat Alterations
Urban Runoff/Storm Sewers - Other Inorganics (Sulfates, etc.)
Urban Runoff/Storm Sewers - Pathogens
Urban Runoff/Storm Sewers - Siltation
Urban Runoff/Storm Sewers - Suspended Solids
Urban Runoff/Storm Sewers - Thermal Modifications
Urban Runoff/Storm Sewers - Unknown Toxicity
Urban Runoff/Storm Sewers - Water/Flow Variability

Table x. TMDL streams data, attributes considered to be agricultural impairments highlighted in blue.

Cause of Impairment
Cause Unknown
Cause Unknown ; Metals
Cause Unknown ; Metals ; pH ; Organic Enrichment/Low D.O.
Cause Unknown ; Metals ; Siltation
Cause Unknown ; Nutrients ; Siltation
Cause Unknown ; Nutrients ; Siltation ; DO/BOD ; Suspended Solids
Cause Unknown ; Nutrients ; Siltation ; Organic Enrichment/Low D.O. ; Suspended Solids ; Turbidity
Cause Unknown ; Nutrients ; TDS
Cause Unknown ; Pesticides ; Nutrients ; Siltation ; Organic Enrichment/Low D.O. ; Suspended Solids
Cause Unknown ; Siltation
Cause Unknown ; Siltation ; Organic Enrichment/Low D.O.
Cause Unknown ; Siltation ; Suspended Solids
Cause Unknown ; Siltation ; Turbidity
Chlordane
Metals
Metals ; Other Inorganics (Sulfates, etc.) ; pH
Metals ; Other Inorganics (Sulfates, etc.) ; pH ; Siltation ; Suspended Solids
Metals ; pH
Metals ; pH ; Siltation
Metals ; pH ; Siltation ; Suspended Solids

Metals ; pH ; Suspended Solids
Metals ; pH ; TDS
Metals ; Siltation
Metals ; Suspended Solids
Metals ; TDS
Nutrients
Nutrients ; Organic Enrichment/Low D.O.
Nutrients ; Siltation
Nutrients ; Siltation ; DO/BOD ; Pathogens
Nutrients ; Siltation ; Organic Enrichment/Low D.O.
Nutrients ; Siltation ; Organic Enrichment/Low D.O. ; DO/BOD
Nutrients ; Siltation ; Organic Enrichment/Low D.O. ; Pathogens
Nutrients ; Siltation ; Organic Enrichment/Low D.O. ; Suspended Solids
Nutrients ; Siltation ; Organic Enrichment/Low D.O. ; Suspended Solids ; Excessive Algal Growth
Nutrients ; Siltation ; Organic Enrichment/Low D.O. ; Suspended Solids ; Turbidity
Nutrients ; Siltation ; Other Habitat Alterations
Nutrients ; Siltation ; Suspended Solids
Nutrients ; Suspended Solids
Organic Enrichment/Low D.O. ; DO/BOD
Organic Enrichment/Low D.O. ; Pathogens ; Suspended Solids ; Turbidity
Pathogens
PCB
PCB ; Chlordane
Pesticides ; PCB ; Chlordane
pH
Priority Organics ; Organic Enrichment/Low D.O. ; Pathogens
Priority Organics ; PCB
Siltation
Siltation ; Organic Enrichment/Low D.O.
Siltation ; Organic Enrichment/Low D.O. ; Other Habitat Alterations
Siltation ; Suspended Solids
Siltation ; Suspended Solids ; Turbidity
Siltation ; Thermal Modifications
Siltation ; Thermal Modifications ; Suspended Solids
Suspended Solids
TDS ; Osmotic Pressure
Thermal Modifications

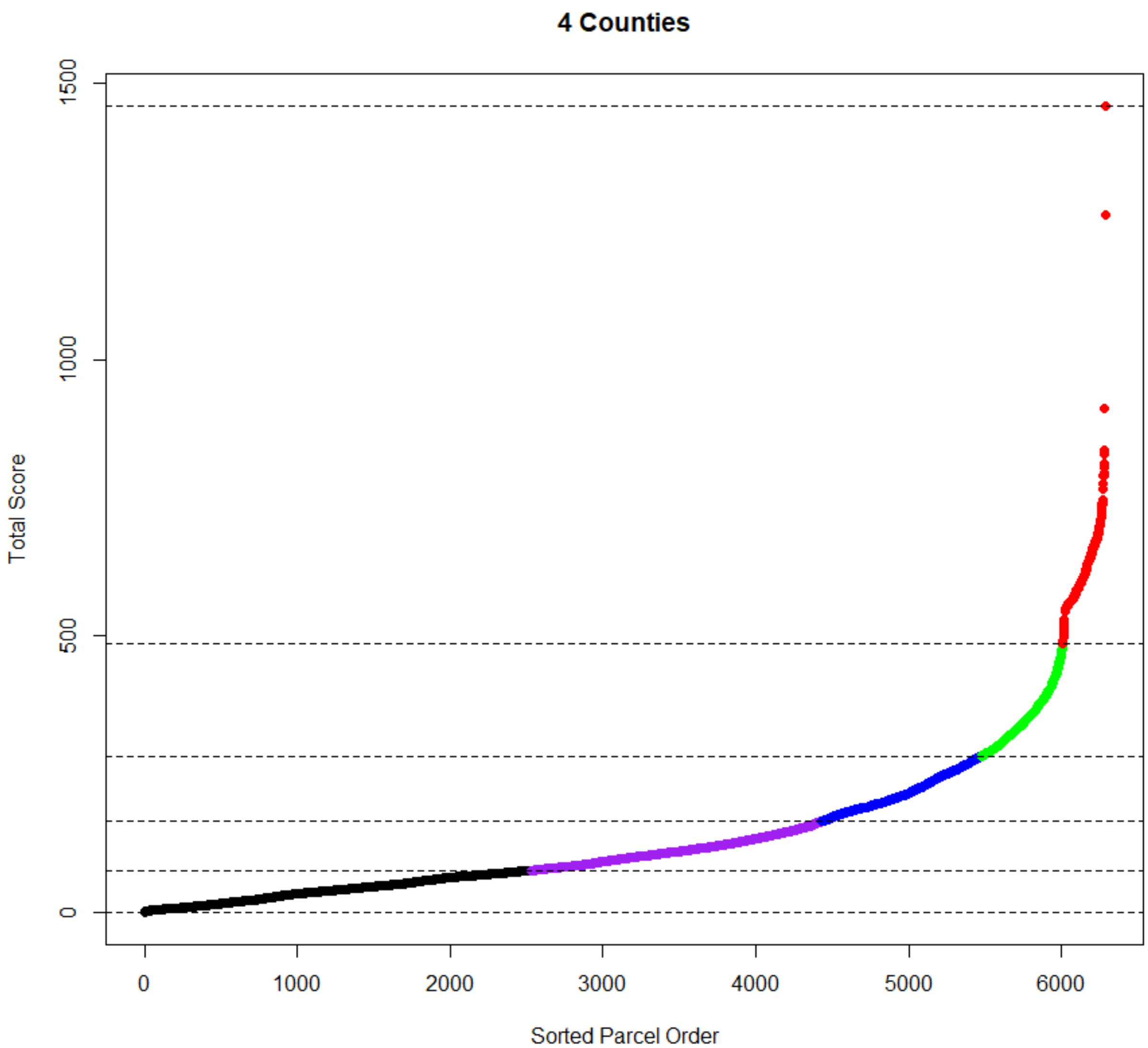

Figure x. Distribution of parcel scores and tier breakdowns in the four county region.

<u>All 4 Counties</u>
Tier 1: 486-1459
Tier 2: 282-486
Tier 3: 164-282
Tier 4: 75-164
Tier 5: 0-75

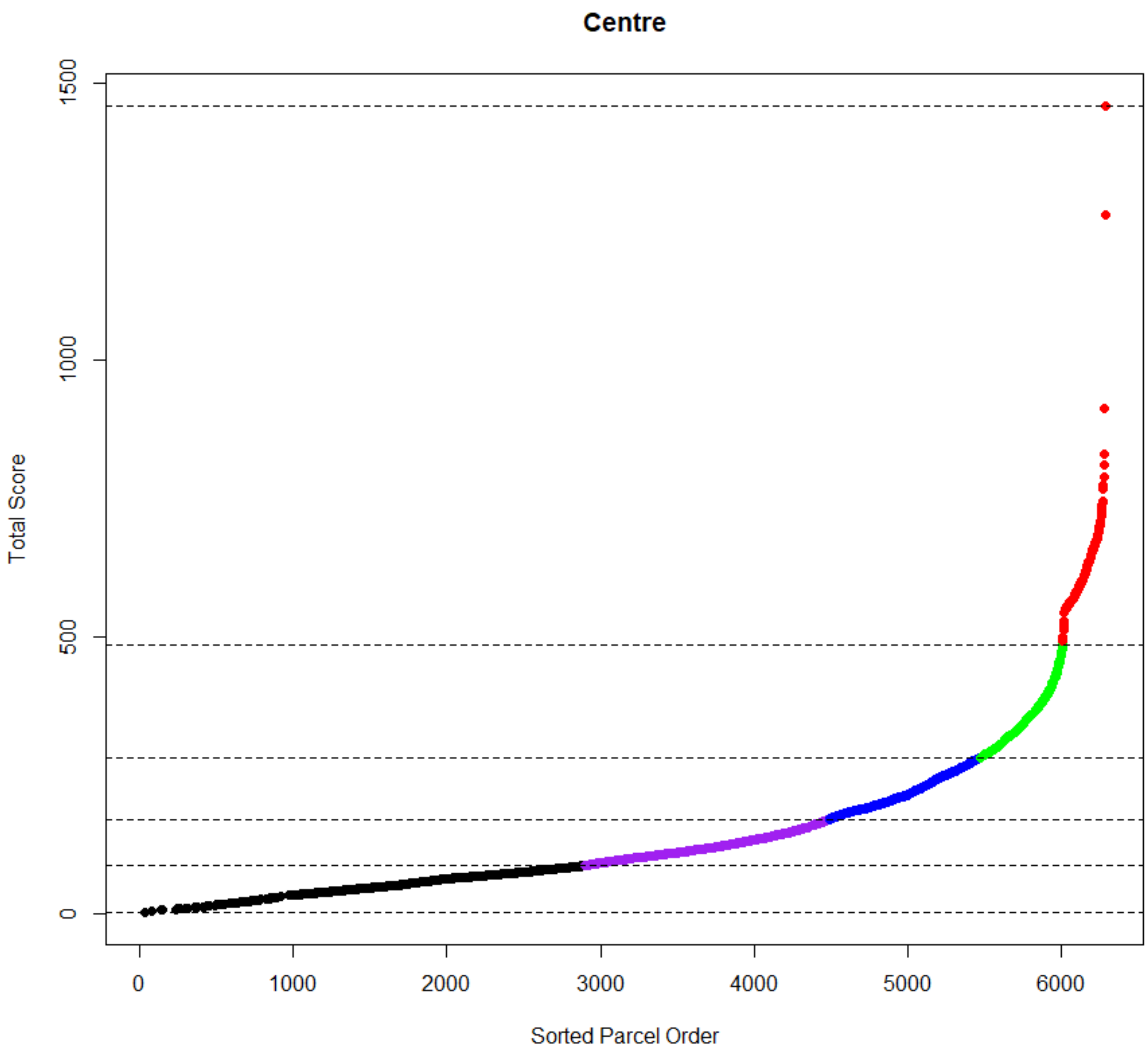

Figure x. Distribution of parcel scores and tier breakdowns in Centre county.

<u>Centre</u>
Tier 1: 485-1459
Tier 2: 281-485
Tier 3: 169-281
Tier 4: 86-169
Tier 5: 0-86

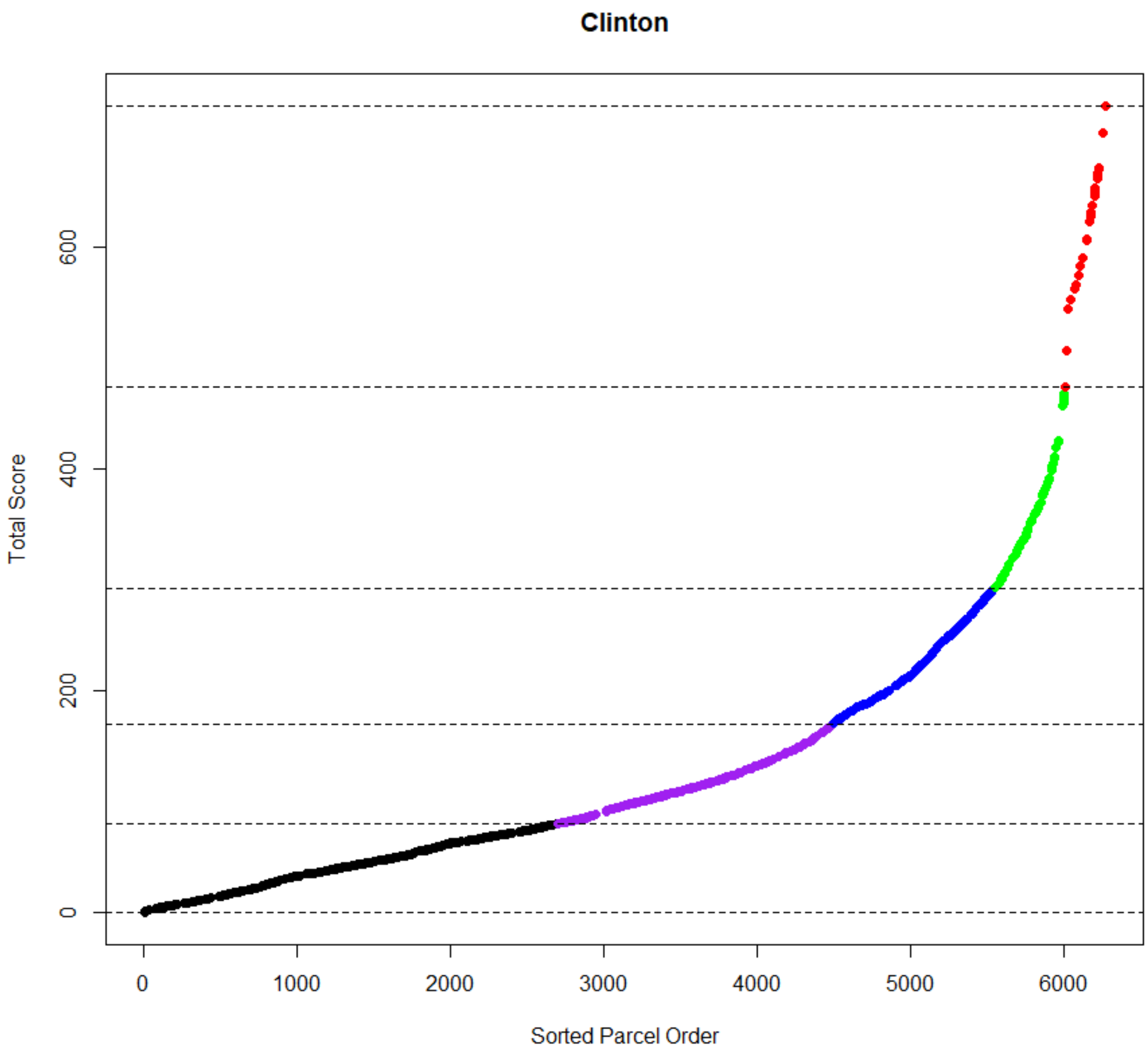

Figure x. Distribution of parcel scores and tier breakdowns in Clinton county.

<u>Clinton</u>
Tier 1: 474-728
Tier 2: 293-474
Tier 3: 170-293
Tier 4: 80-170
Tier 5: 0-80

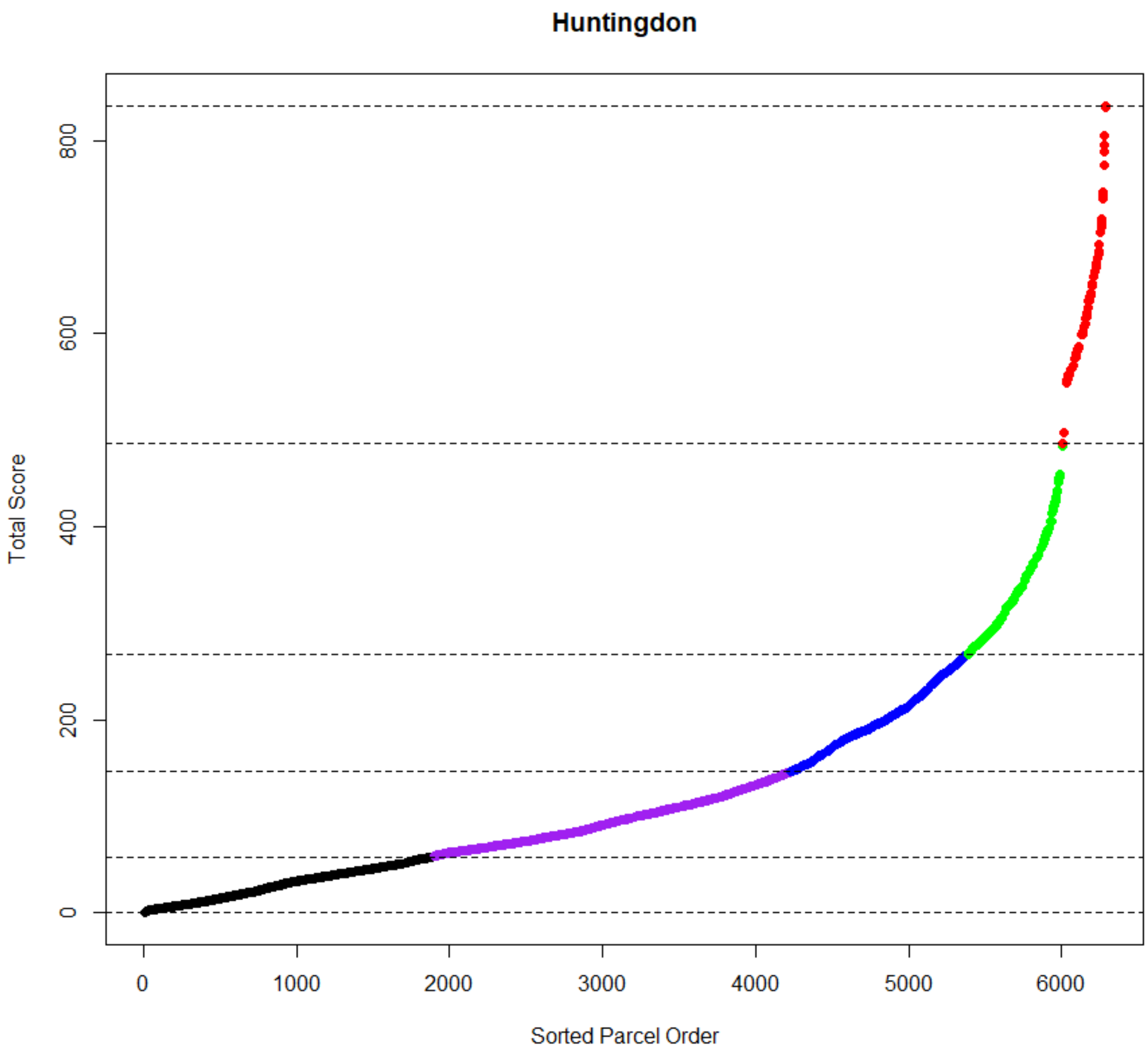

Figure x. Distribution of parcel scores and tier breakdowns in Huntingdon county.

<u>Huntingdon</u>
Tier 1: 486-835
Tier 2: 268-486
Tier 3: 146-268
Tier 4: 58-146
Tier 5: 0-58

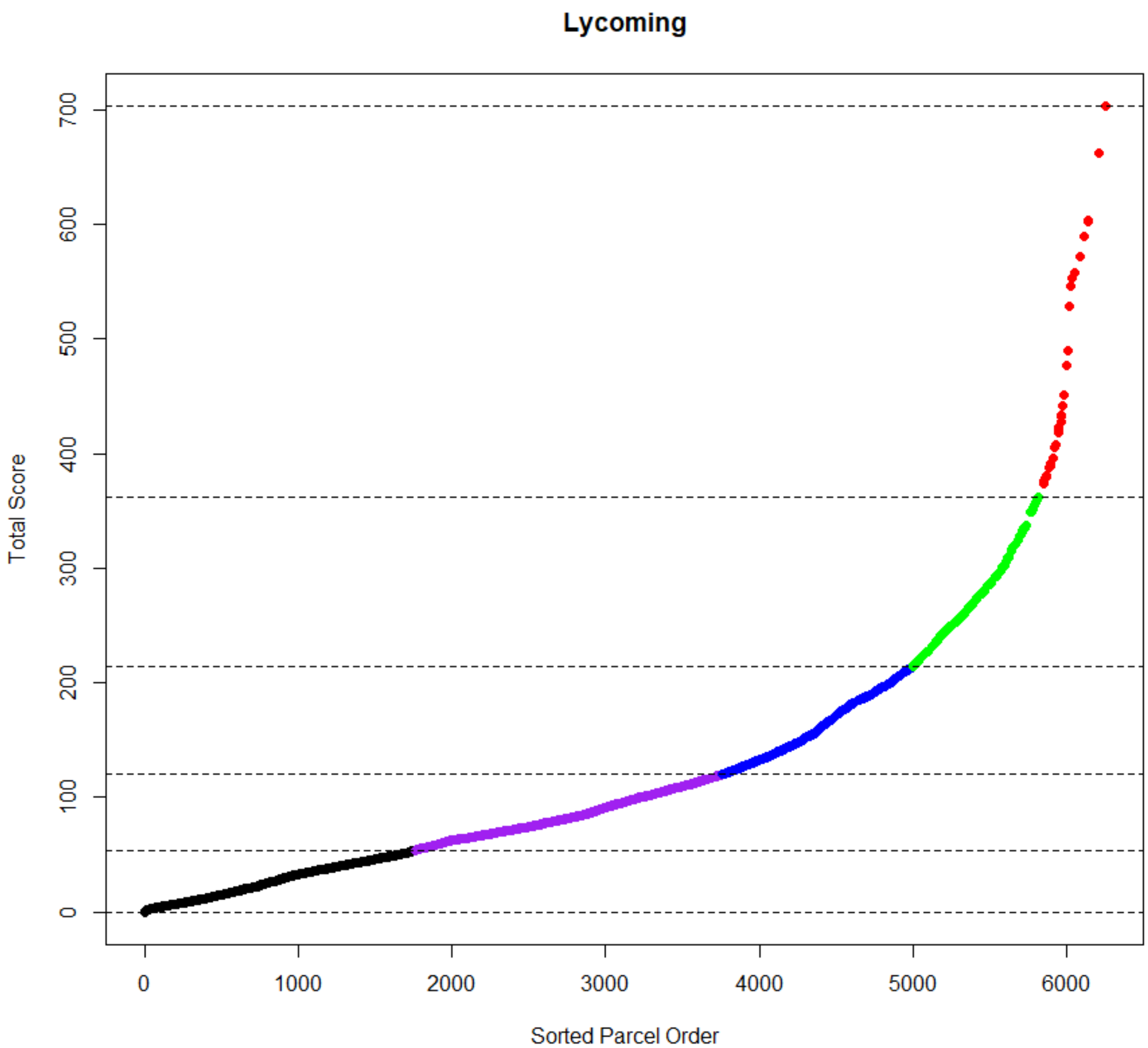

Figure x. Distribution of parcel scores and tier breakdowns in Lycoming county.

<u>Lycoming</u>
Tier 1: 362-703
Tier 2: 214-362
Tier 3: 120-214
Tier 4: 54-120
Tier 5: 0-54

R Script: Determining rank and tiers for parcels in the 4 county region and in each individual county using natural breaks (Jenks) method.

```
#ETS Prioritization

#Final Score distribution

library(dplyr)

library(rgdal)

library(sp)

library(binr)

library(BAMMtools)


par<- readOGR("Deliverables/Parcels.gdb", "FinalScores", verbose=FALSE)

names(par)


par2<- par[order(par$TotalScore), ]

par2$n <- seq(1:length(par2))

print(par2[1:10,])


hist(par2$TotalScore)


lyc<- par2[par2$County == "Lycoming",]

hunt<- par2[par2$County == "Huntingdon",]

clin<- par2[par2$County == "Clinton",]

cent<- par2[par2$County == "Centre",]


hist(lyc$TotalScore)

hist(hunt$TotalScore)

hist(clin$TotalScore)

hist(cent$TotalScore)
```

```
print(max(par2$TotalScore))

print(min(par2$TotalScore))


plot(par2$n, par2$TotalScore, pch = 19, col = par2$color, main = "4 Counties", xlab = "Sorted Parcel Order", ylab = "Total Score")

abline(h=.08, lty = 2)

abline(h=75, lty = 2)

abline(h=164, lty =2)

abline(h=282, lty =2)

abline(h=486, lty =2)

abline(h=1459, lty =2)

#abline(v=1459)


par2$tier<- ifelse(par2$TotalScore <= 75, 5,

                ifelse(par2$TotalScore <= 164 & par2$TotalScore >75, 4,

                      ifelse(par2$TotalScore <= 282 & par2$TotalScore >164, 3,

                        ifelse(par2$TotalScore <= 486 & par2$TotalScore >282, 2, 1))))

par2$color<- ifelse(par2$tier ==1, "red",

               ifelse(par2$tier == 2, "green",

                     ifelse(par2$tier == 3, "blue",

                           ifelse(par2$tier == 4, "purple", "black"))))

par2$rank<- rev(seq(1:length(par2)))

scores<- as.vector(par2$TotalScore)

getJenksBreaks(scores, 6)

#[1] 8.804604e-02 7.568803e+01 1.641677e+02 2.821500e+02 4.862200e+02 1.458508e+03


write.csv(par2, "Deliverables/4cos_tiers.csv")

writeOGR(par2, "Deliverables/RankTierData", "4Cowranks", driver = "ESRI Shapefile")
```

```
#per county

#lycoming


scoresl<- as.vector(lyc$TotalScore)

getJenksBreaks(scoresl, 6)

#[1]   0.08804604  54.16382980 119.91718292 213.90922546 361.84249878 702.86932373


lyc$tier<- ifelse(lyc$TotalScore <= 54, 5,

                ifelse(lyc$TotalScore <= 120 & lyc$TotalScore >54, 4,

                      ifelse(lyc$TotalScore <= 214 & lyc$TotalScore >120, 3,

                            ifelse(lyc$TotalScore <= 362 & lyc$TotalScore >214, 2, 1))))

lyc$color<- ifelse(lyc$tier ==1, "red",

                 ifelse(lyc$tier == 2, "green",

                       ifelse(lyc$tier == 3, "blue",

                             ifelse(lyc$tier == 4, "purple", "black"))))

plot(lyc$n, lyc$TotalScore, pch = 19, col = lyc$color, xlab= "Sorted Parcel Order", ylab = "Total Score",
main = "Lycoming")

abline(h=.08, lty=2)

abline(h=54, lty=2)

abline(h=120, lty=2)

abline(h=214, lty=2)

abline(h=362, lty=2)

abline(h=703, lty=2)


write.csv(lyc, "Deliverables/lyc.csv")



#huntingdon
```

```
scoresh<- as.vector(hunt$TotalScore)

getJenksBreaks(scoresh, 6)

#[1]   1.087489  57.865589 145.732605 268.036713 486.220001 835.406311



hunt$tier<- ifelse(hunt$TotalScore <= 58, 5,
                ifelse(hunt$TotalScore <= 146 & hunt$TotalScore >58, 4,
                    ifelse(hunt$TotalScore <= 268 & hunt$TotalScore >146, 3,
                        ifelse(hunt$TotalScore <= 486 & hunt$TotalScore >268, 2, 1))))

hunt$color<- ifelse(hunt$tier ==1, "red",
                 ifelse(hunt$tier == 2, "green",
                     ifelse(hunt$tier == 3, "blue",
                         ifelse(hunt$tier == 4, "purple", "black"))))

plot(hunt$n, hunt$TotalScore, pch = 19, col = hunt$color, xlab= "Sorted Parcel Order", ylab = "Total Score", main = "Huntingdon")

abline(h=1.08, lty=2)

abline(h=58, lty=2)

abline(h=146, lty=2)

abline(h=268, lty=2)

abline(h=486, lty=2)

abline(h=835, lty=2)


write.csv(hunt, "Deliverables/hunt.csv")


#clinton


scorescl<- as.vector(clin$TotalScore)

getJenksBreaks(scorescl, 6)

#[1]   0.6221461  80.1766434 169.9594269 293.4478455 474.3117981 727.6386719
```

```
clin$tier<- ifelse(clin$TotalScore <= 80, 5,
        ifelse(clin$TotalScore <= 170 & clin$TotalScore >80, 4,
            ifelse(clin$TotalScore <= 293 & clin$TotalScore >170, 3,
                ifelse(clin$TotalScore <= 474 & clin$TotalScore >293, 2, 1))))
clin$color<- ifelse(clin$tier ==1, "red",
        ifelse(clin$tier == 2, "green",
            ifelse(clin$tier == 3, "blue",
                ifelse(clin$tier == 4, "purple", "black"))))
plot(clin$n, clin$TotalScore, pch = 19, col = clin$color, xlab= "Sorted Parcel Order", ylab = "Total Score", main = "Clinton")
abline(h=.62, lty=2)
abline(h=80, lty=2)
abline(h=170, lty=2)
abline(h=293, lty=2)
abline(h=474, lty=2)
abline(h=728, lty=2)

write.csv(clin, "Deliverables/clin.csv")


#centre
scoresc<- as.vector(cent$TotalScore)
getJenksBreaks(scoresc, 6)
#[1]    2.47296   86.24488  168.86259  281.20050  484.64270 1458.50806


cent$tier<- ifelse(cent$TotalScore <= 86, 5,
```

```
                ifelse(cent$TotalScore <= 169 & cent$TotalScore >86, 4,
                      ifelse(cent$TotalScore <= 281 & cent$TotalScore >169, 3,
                            ifelse(cent$TotalScore <= 485 & cent$TotalScore >281, 2, 1))))

cent$color<- ifelse(cent$tier ==1, "red",
                 ifelse(cent$tier == 2, "green",
                       ifelse(cent$tier == 3, "blue",
                             ifelse(cent$tier == 4, "purple", "black"))))

plot(cent$n, cent$TotalScore, pch = 19, col = cent$color, xlab= "Sorted Parcel Order", ylab = "Total Score", main = "Centre")

abline(h=2.5, lty=2)

abline(h=86, lty=2)

abline(h=169, lty=2)

abline(h=281, lty=2)

abline(h=485, lty=2)

abline(h=1459, lty=2)


write.csv(cent, "Deliverables/cent.csv")


#merge all county tiers

cotiers<-rbind(lyc, hunt, clin, cent)

write.csv(cotiers, "Deliverables/TiersbyCo.csv")

writeOGR(cotiers, "Deliverables/RankTierData", "Coranks", driver = "ESRI Shapefile")


#in Excel sort TiersbyCo by n, copy last column and make a new column in 4Cos spreadsheet, "CoTier"
#done.


#add county rank

lyc$corank<- rev(seq(1:length(lyc)))

hunt$corank<- rev(seq(1:length(hunt)))
```

```
clin$corank<- rev(seq(1:length(clin)))

cent$corank<- rev(seq(1:length(cent)))


#summary

for (i in 1:5)

{print(length(par2[par2$tier == i, ]))}


for (i in 1:5)

{print(length(lyc[lyc$tier == i, ]))}


for (i in 1:5)

{print(length(hunt[hunt$tier == i, ]))}


for (i in 1:5)

{print(length(clin[clin$tier == i, ]))}


for (i in 1:5)

{print(length(cent[cent$tier == i, ]))}


#wrote out shapefiles of par2 "4Cowranks" and merged cotier "Coranks".

#joined county tiers and ranks to 4Cowranks shapefile

#then joined 4Cowranks to Final Scores "Deliverables/Parcels.gdb/FinalScores.
```