Using Remote Sensing to Identify Size and Condition of Kansas Windbreaks

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KANSAS 125 YEARS 1887 2012 FOREST SERVICE KANSAS STATE UNIVERSITY

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

CORONADO CROSSING RC&D

gissal
Geographic Information Systems
Spatial Analysis Laboratory

Project Background

- Lack of Data on Windbreak Size, Condition and Location of Windbreaks
- Strong Windbreak Renovation Interest in SW Kansas
- 2008 – Project Award - 1st Year for USFS S & P Western Competitive Resource Allocation – "Redesign" ($116,567)
- **2008 - 2009 Great Plains Tree and Forest Invasives Initiative Inventory**
  - 2.9 million acres – 84% "isolated trees" without a specific function
  - 289,577 acres of windbreaks totaling 43,436 miles long
  - Protects 1.2 million acres (59% field, 28% farmstead, 12% livestock)
  - Condition - 56% good, 44% fair to poor
  - Age – 59% 25-50 yrs., 21% older than 50 yrs., 20% less than 25 yrs.
  - Species (in millions of trees) – Osage orange 17, hackberry 15, eastern redcedar 8, American elm 5, Siberian elm 4, green ash 1

Project Timeline
2008 USFS Grant Application
2009 Mike Dulin's Thesis – Ford County
2010 Kabita Ghimire
2011 Ground Truthing

Neeravi Nepal
Aug. 26, 2011

Major Goals

1. Identify the location, size and condition of field windbreaks

2. Identify priority areas where windbreak establishment is most effective in reducing windblown soil

3. Assign ecosystem service values to the windbreaks

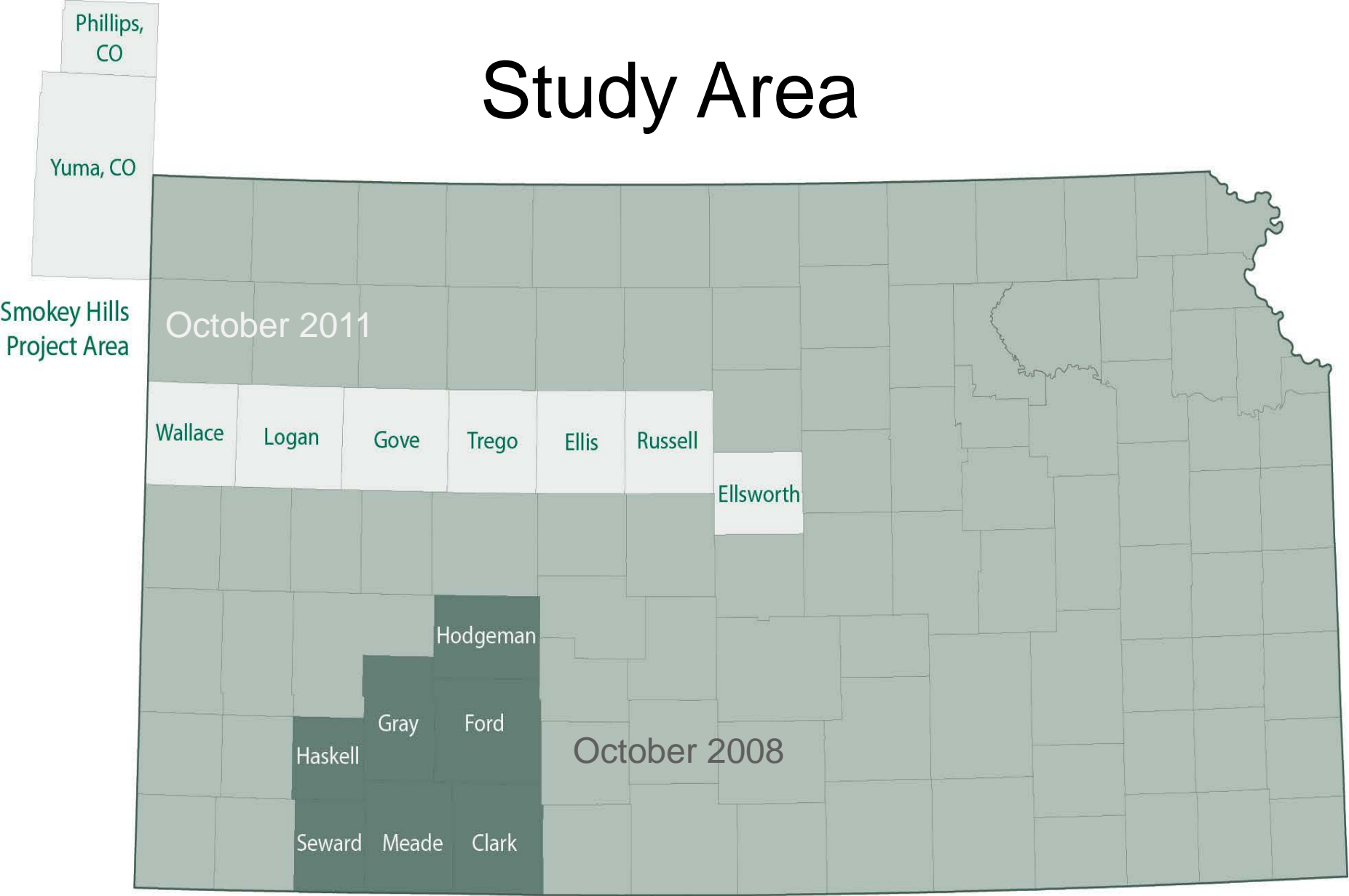4. **Increase implementation of windbreak renovation practices**

Specific objectives

- Rapidly classify windbreaks using Object Based Classification of remote sensing images

- Develop a secondary classification to assess windbreak condition (good, fair, poor) using same criteria that NRCS uses to qualify windbreaks as an EQIP "resource concern"

- Determine the number of acres/hectares that exists in each class

- Interface landownership GIS layer with poor condition GIS layer to target promotion of windbreak renovation

Study Area

Phillips, CO

Yuma, CO

Smokey Hills Project Area

October 2011

Wallace Logan Gove Trego Ellis Russell

Ellsworth

Hodgeman

Gray Ford

Haskell

October 2008

Seward Meade Clark

Study Area: Coronado Crossings Resource Conservation and Development Area

National Agriculture Imagery Program (NAIP)

– 2008 4 band color aerial imagery tiled by county in 1-meter resolution

– 2006 CIR (colored infrared imagery) tiled by county in 1-meter resolution

– The 2008 NAIP imagery was collected during the growing season during the months of June and July

Gray county NAIP 2008 Image
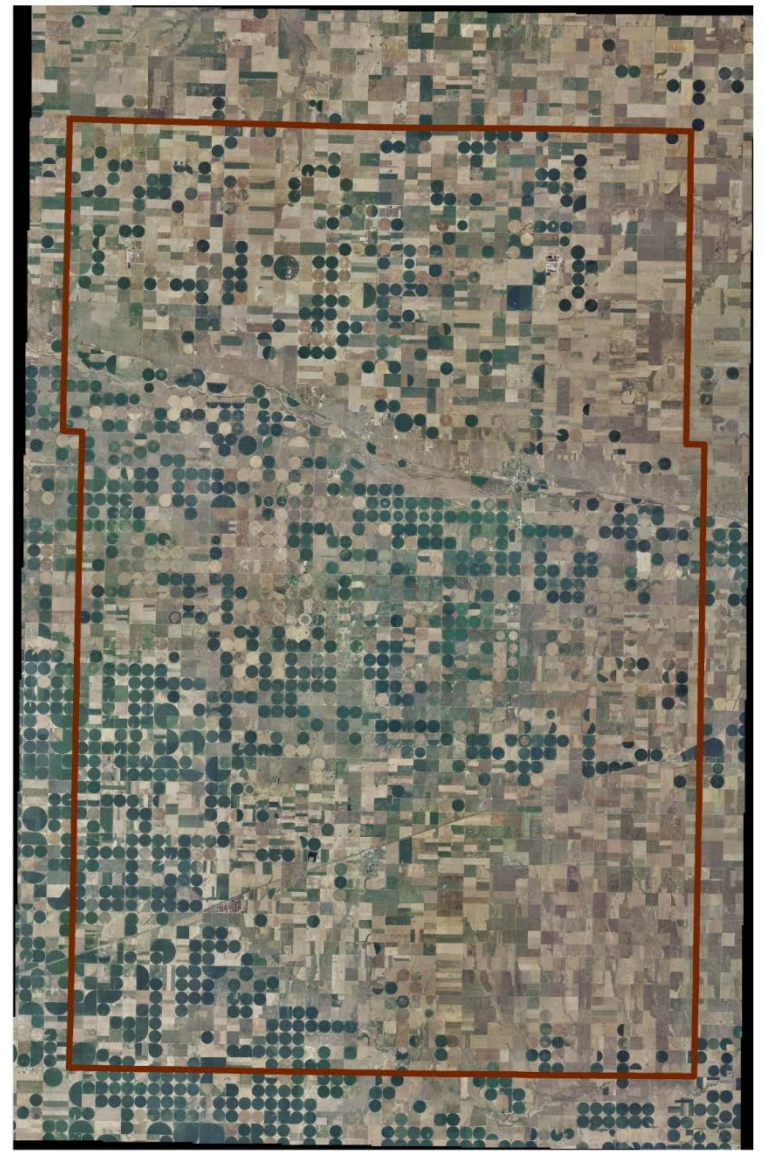

Gray county boundary overlay

5 Step Methodology

- Image pre-processing

- Object based classification using ENVI Zoom 4.5

- Windbreak Class extraction

- Editing of windbreak features and attributes in Arc GIS

- Assessment and area calculation

Image preprocessing

– Resampling of NAIP images with ArcMap

- Using the nearest neighbor technique at a factor of 6

- To reduce the image file size

- Speed up computer processing

- Resampling also transformed windbreaks into more homogeneous areas of pixels rather than isolated cells containing a single tree within a windbreak
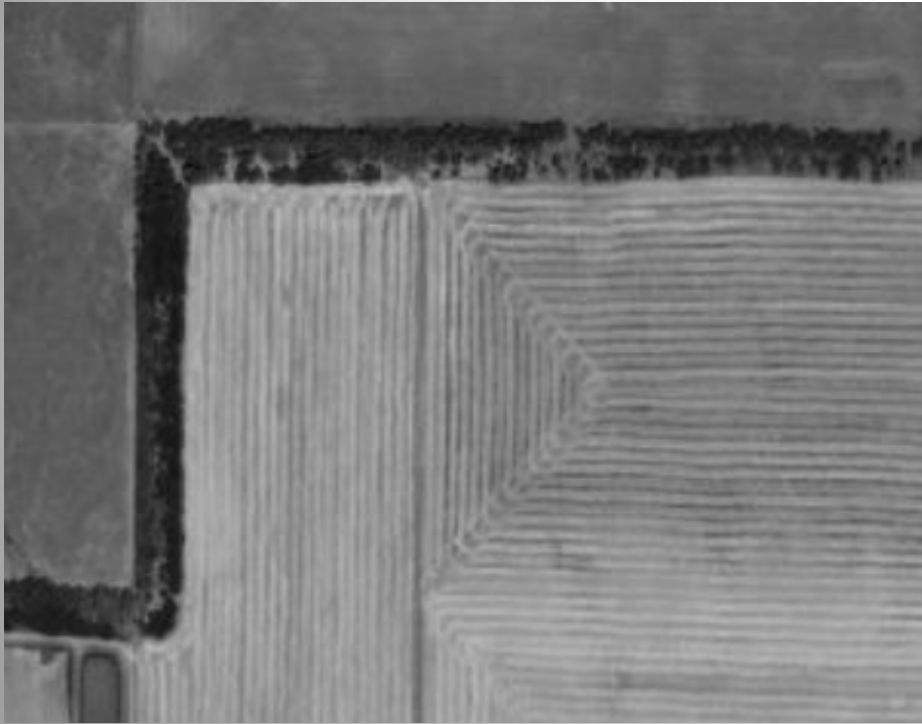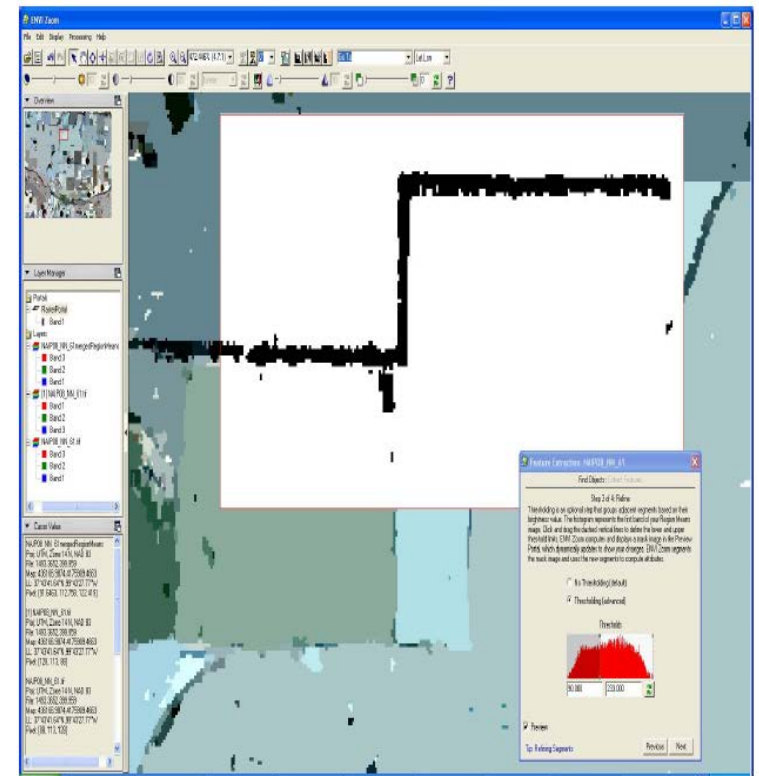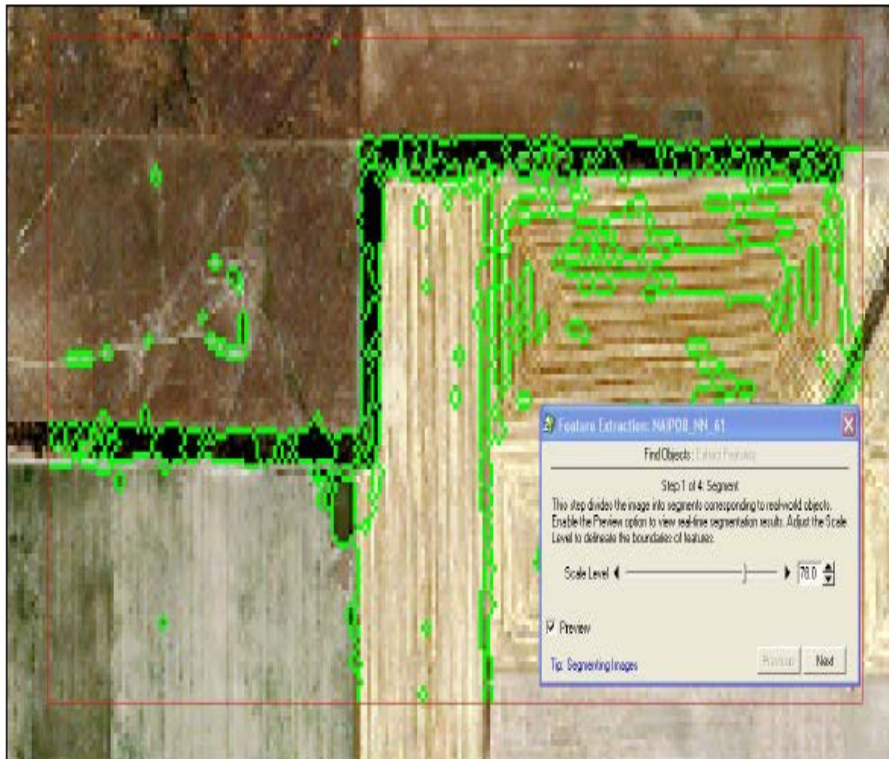
Original (1 M)
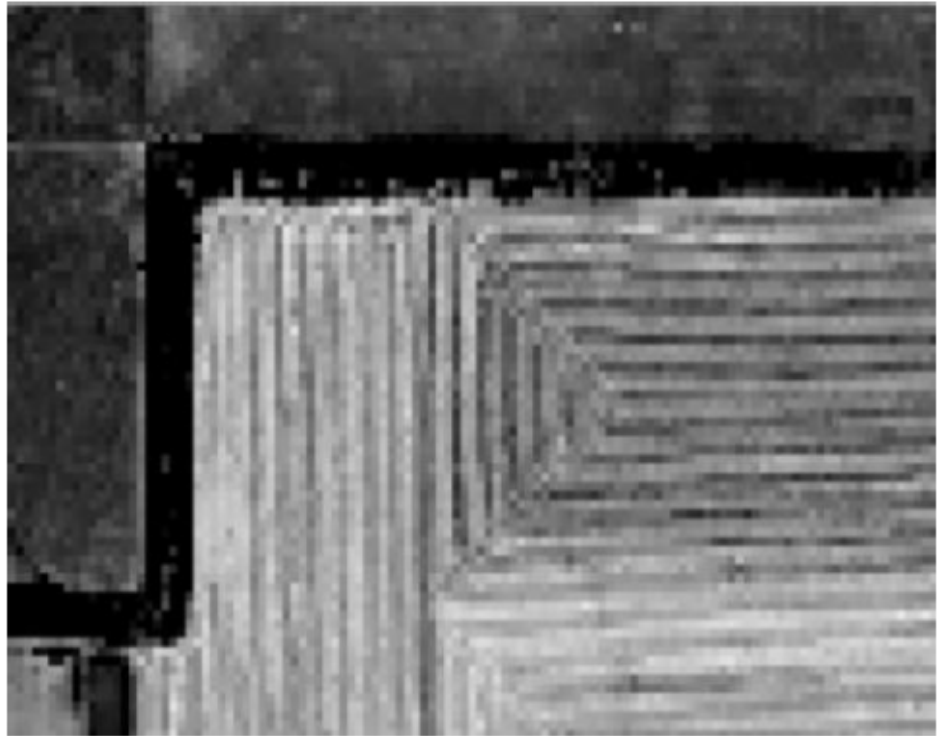
Resampled (6 M)

Object Based Classification - ENVI Zoom 4.5

Feature Extraction – IDs different objects and puts them into blocks of similar pixels.

Segmentation and merging   **Thresholding and Masking**

Land Use/ Land Cover Classification

LULC Type	Description
Crops	Live row crops including center pivot irrigation land
Tree Stands	Individual stands of trees/shrubs not linear in nature and not near water features
Riparian	Long irregularly shaped stands of trees bordering water features
Windbreaks	Linear Strips of trees planted near farm houses and crop fields likely to have jagged edges conforming to the shape of outer edge trees
Manicured Landscape	Vegetative features such as Golf Courses and Lawns under apparent human management
Ditches	Extremely long linear features running parallel to roads and rail road tracks containing few trees and smooth edges

Training ENVI Zoom 4.5 to Identify Objects By Land Use/Cover Class

Cover Type	Number of Training Sites By County							
	Ford	Gray	Clark	Hodgeman	Haskell	Meade	Seward	Total
Crops	35	52	50	50	50	50	50	337
Ditches	15	22	38	25	25	25	25	175
Manicured Landscapes	6	10	10	5	5	5	5	46
Riparian	20	18	83	85	20	75	50	351
Tree Stands	50	63	75	50	30	50	30	348
Windbreaks	**45**	35	65	65	10	50	10	280
Total samples	**171**	**200**	**321**	**280**	**140**	**255**	**170**	**1537**

In Gray County 200 sites were used to classify 33,911 total objects

Exporting objects into shapefiles

Classified Objects overlaid on the original Image
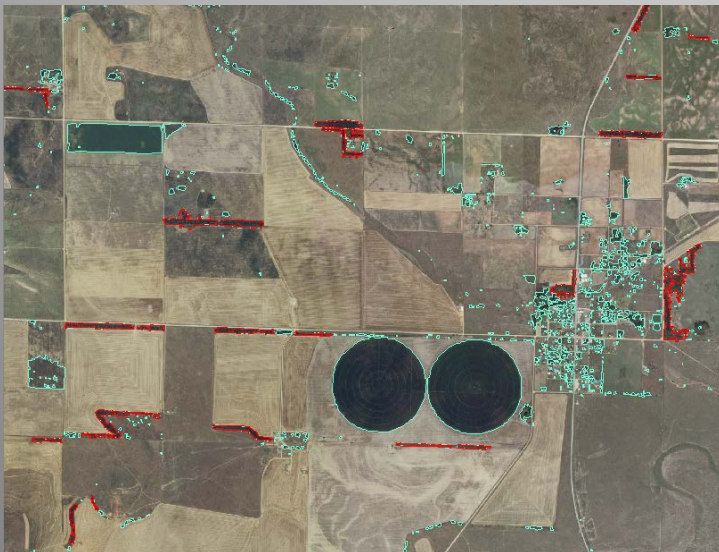
Counties	Number of objects classified
Ford	51,202
Gray	33,911
Clark	64,518
Hodgeman	33,853
Haskell	15,909
Meade	40,576
Seward	30,173

Classification Accuracy – Ford County

	NWB	WB	Row Total	User Accuracy
NWB	**1115**	63	1178	94.65%
WB	36	**119**	155	76.77%
Column total	1151	182	1333	
Producer Accuracy	96.87%	65.38%	**Overall Accuracy**	92.57%
Kappa is a statistical measure of agreement that could be expected due to chance alone. 66.4% means substantial agreement (model prediction & reality)				66.4% Kappa

- 63 of 1,178 NWB objects were misclassified as windbreaks
- Out of 155 objects in the WB class, 119 were actually windbreaks

Working with ArcGIS

- Windbreak Class extraction (getting rid of NWB objects)
- Editing windbreak features and attributes in Arc GIS
- Assessment and area calculation
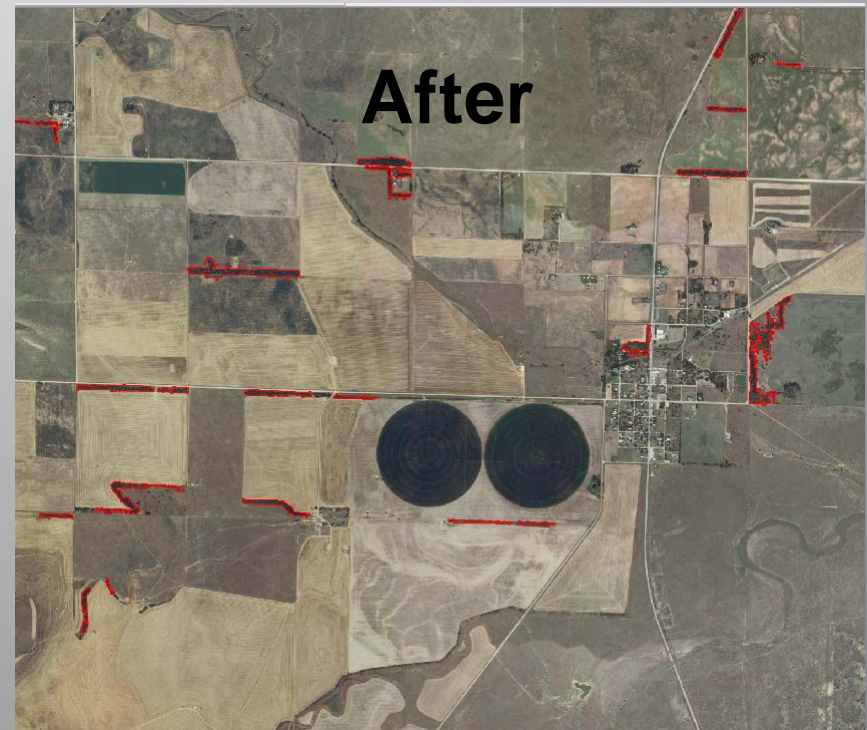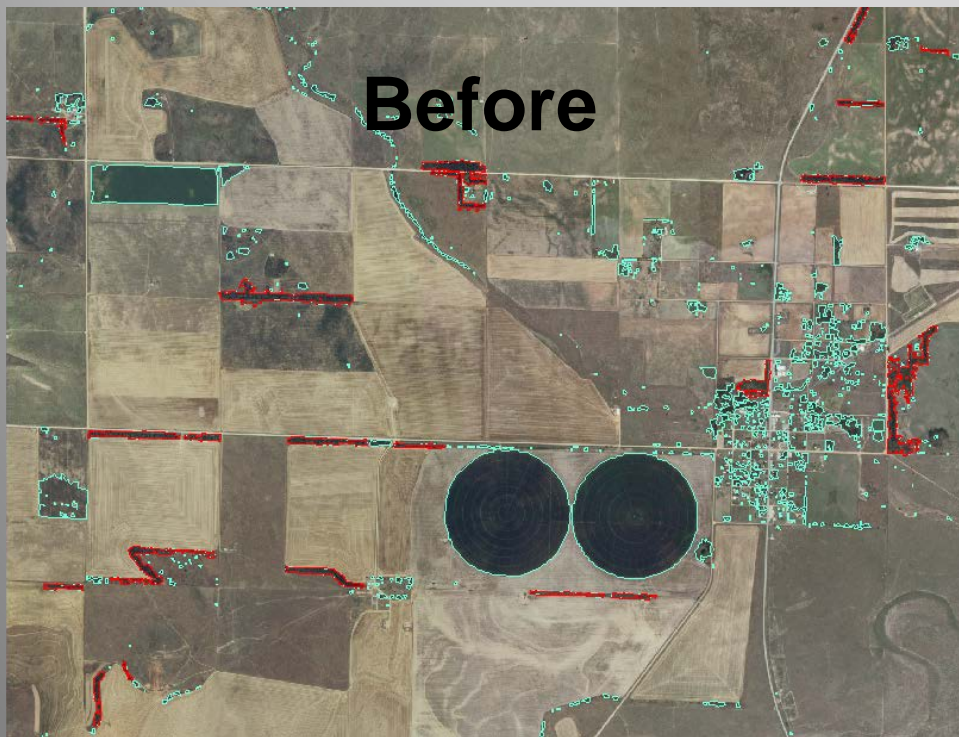
Consolidating Poor Condition Windbreaks into One Windbreak

Clark County Windbreak Locations

166 windbreaks
729 acres
1,981 acres protected
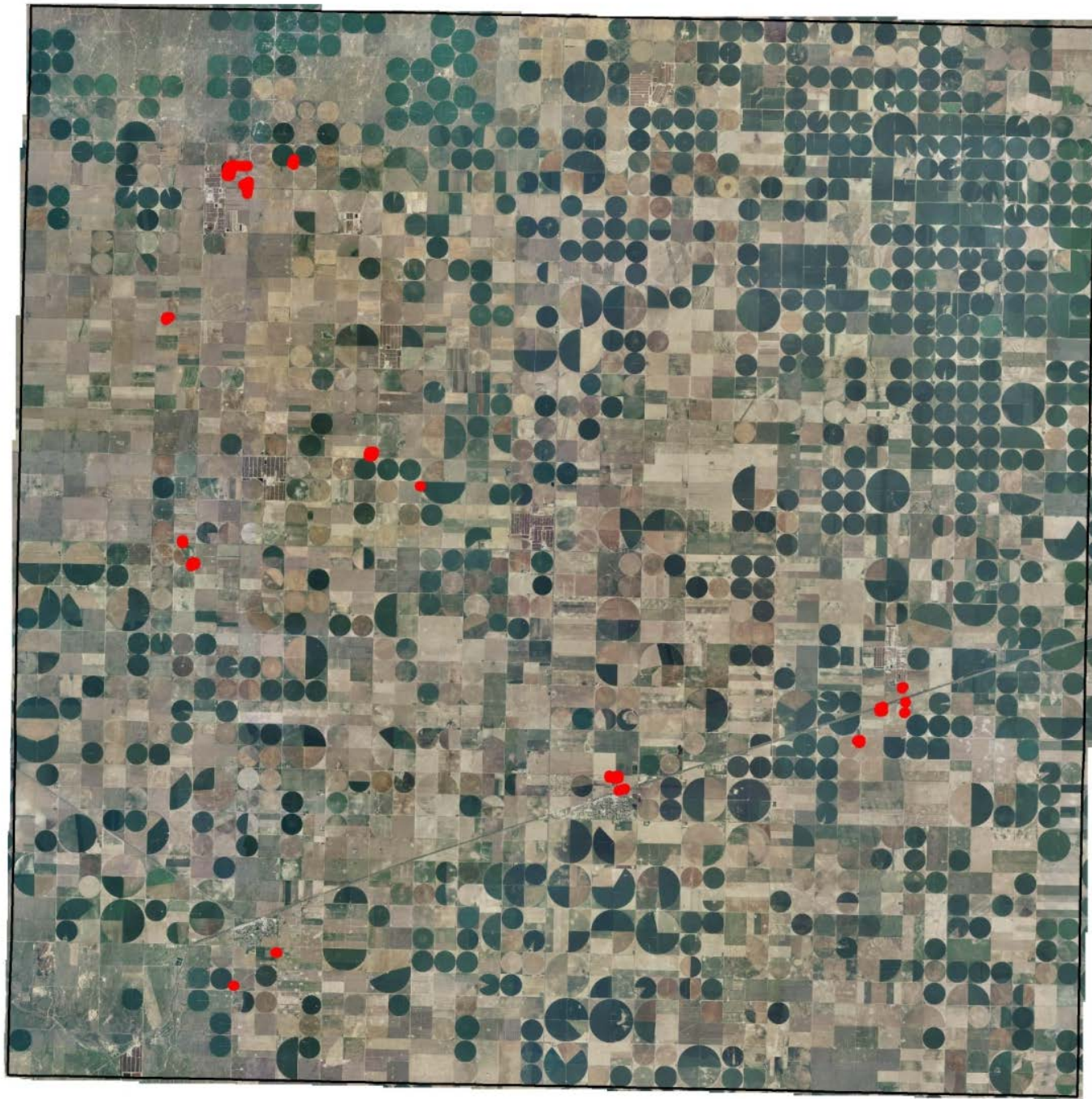55 miles
30 ft. AV HT

Windbreaks
County Boundary
NAIP Image

Haskell County Windbreak Locations

22 windbreaks
26 acres
98 acres protected

Windbreaks
County Boundary
NAIP Image

Wind Erodibility Index of 86+

❑ **Provides some guidance for potential new CRP practices 488 (48%) WEI 86+ (green dots)**

❑ **A total of 1,116 windbreaks covering 2,597 acres**

❑ **Total of 8,202 Acres Protected (3,319 Hectares) (10 x AV HT of 30 FT)**

Cornado Crossings Windbreak Project

Windbreaks

Located on wei 86+ soils?

- Yes
- No

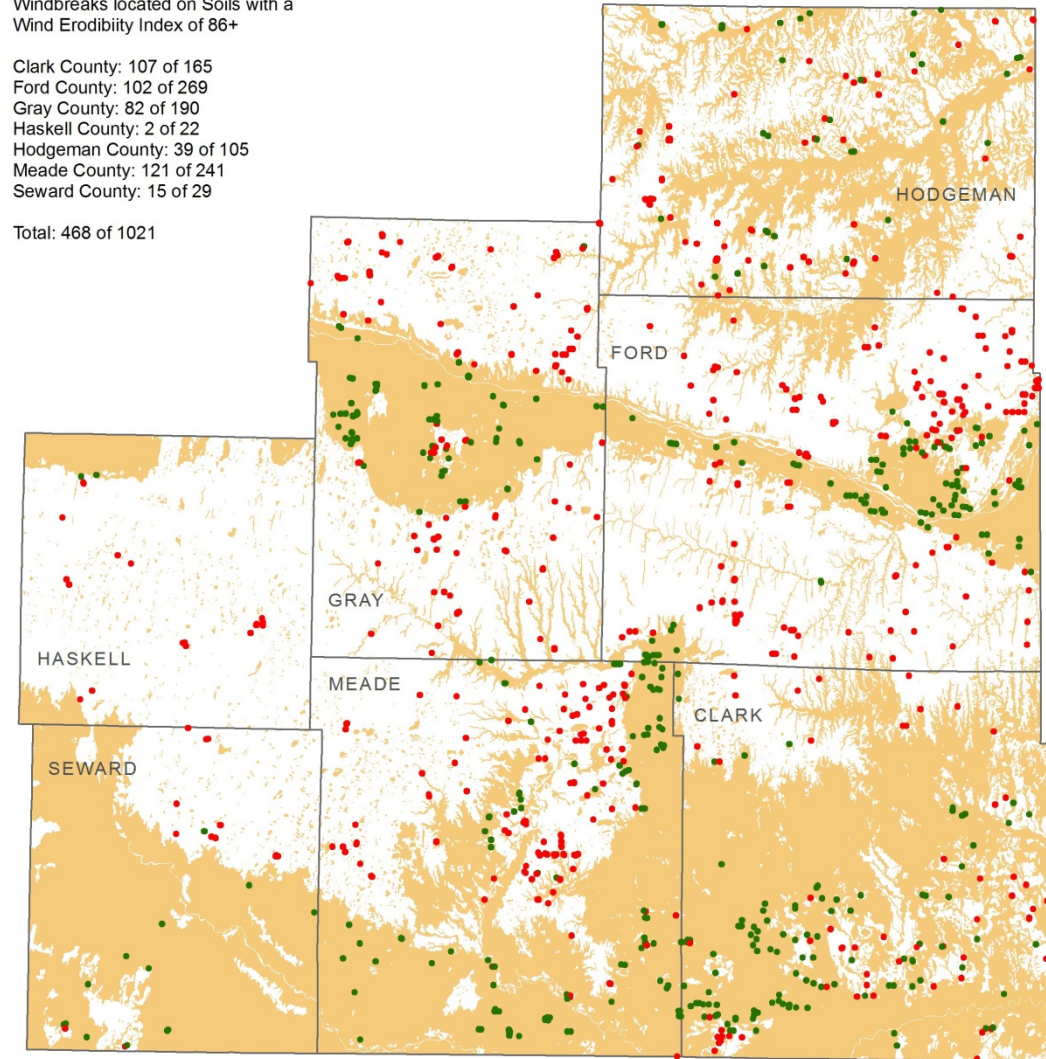Soils with Wind Eodibility Index of 86+

County Boundaries

Windbreaks located on Soils with a Wind Erodibiity Index of 86+

Clark County: 107 of 165
Ford County: 102 of 269
Gray County: 82 of 190
Haskell County: 2 of 22
Hodgeman County: 39 of 105
Meade County: 121 of 241
Seward County: 15 of 29

Total: 468 of 1021

HODGEMAN

FORD

GRAY

HASKELL

MEADE

CLARK

SEWARD

Number of Windbreaks 7 counties
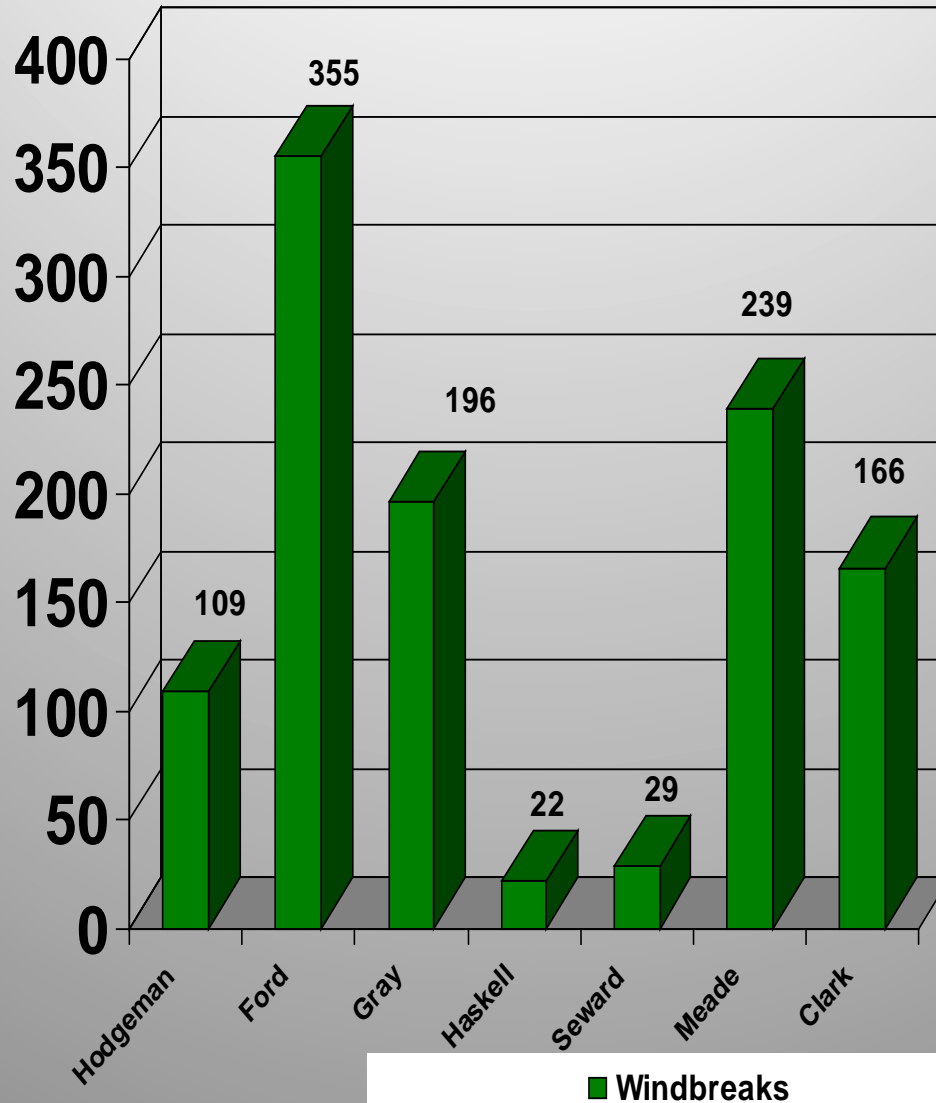
Area of WB in 7 counties

County	Number of Windbreaks	Area covered by Windbreaks	
		Acres	Hectares
Gray	196	222.5538	90.064
Haskell	22	26.9154	10.89
Seward	29	26.170	10.590
Clark	166	728.8169	294.941
Ford	355	1011.9	409.5
Hodgeman	109	140.538	56.8737
Meade	239	440.451	178.244
Total	**1116**	**2597.3451**	**1051.1027**

Total of 8,202 Acres Protected (3,319 Hectares) (10 x AV HT of 30 FT)

Area of WB in 7 counties
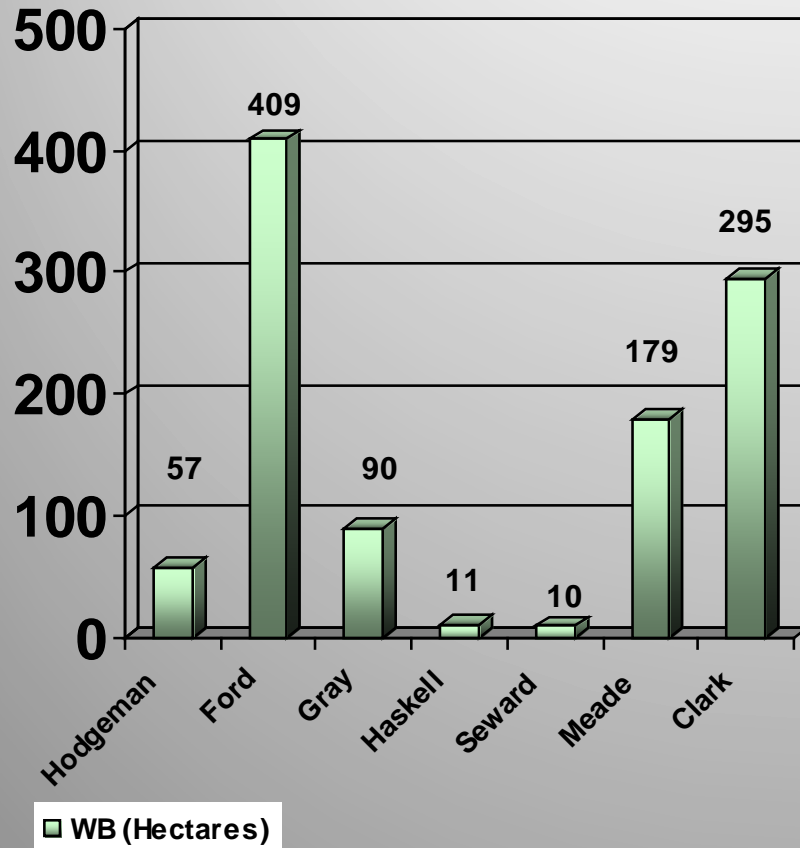
Condition Assessment Criteria

KANSAS FORESTRY TECHNICAL NOTE KS-11

- Less than 25 percent of the trees are dead
- Continuous barrier; no gaps
- 50 percent density or greater
- No smooth bromegrass or fescue sod
- No livestock activity in the windbreak
- Tree regeneration is present
- Windbreak will live/function another 20 years

Condition Classes

- **Good –** At least seven of the attributes describe the windbreak; (one includes less than 25 percent of the trees are dead)

- **Fair –** At least five of the attributes describe the windbreak; (one includes less than 25 percent of the trees are dead)

- **Poor –** At least four of the attributes describe the windbreak; more than 25 percent tree mortality

Condition Assessment

- **Brightness Value (Average green reflectance value), band 2**

  Low BV = Lower reflectance =Good WB condition

  High BV = High reflectance = Poor WB condition

- **Texture Analysis**

  High textural value = Coarser feature = Poor WB condition

  Lower textural value = Finer feature = Good WB condition

- **Normalized Difference Vegetation Index (NDVI)**
  - NDVI value ranges from 0.0 to 1.0
  - High NDVI = Good Vegetation Health = Good WB condition
  - Lower NDVI = Poor Vegetation Health = Poor WB condition

- **Ground Truth Information**
  - based on windbreak condition class evaluation guide

Brightness Value

- **Average green reflectance value**, band 2

  Low BV = Lower reflectance =**Good WB** condition

  (nothing is being reflected from the ground – good canopy, few gaps)

  High BV = High reflectance = **Poor WB** condition

Range of the Brightness Value (BV)
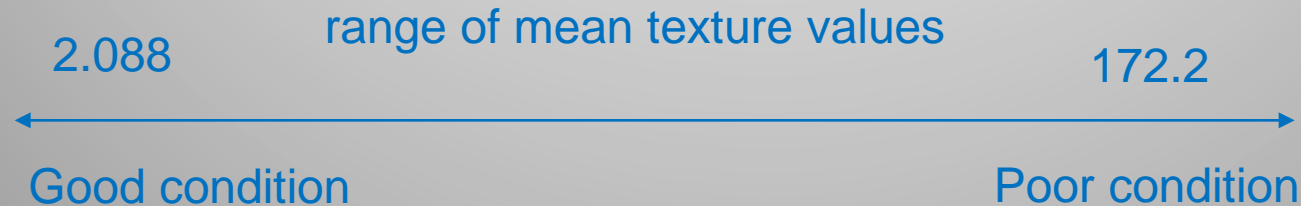
17.0

171.0

Good condition
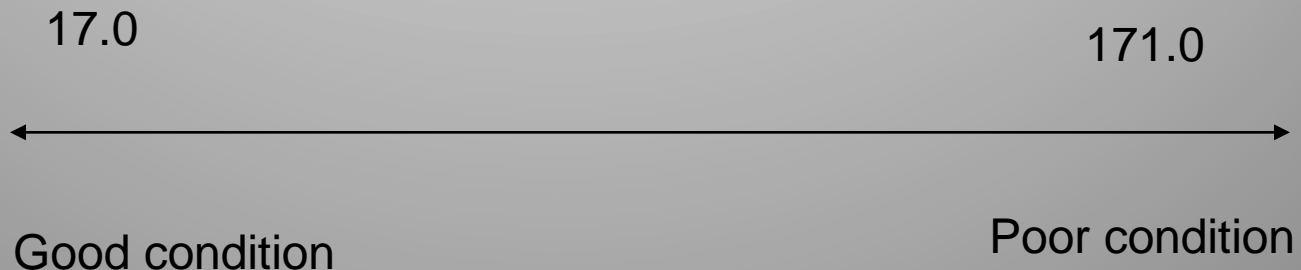
Poor condition

Texture Analysis

High textural value = Poor WB condition
rough, patchy features, gaps

Lower textural value = Good WB condition
finer features

range of mean texture values

2.088   172.2

Good condition   Poor condition

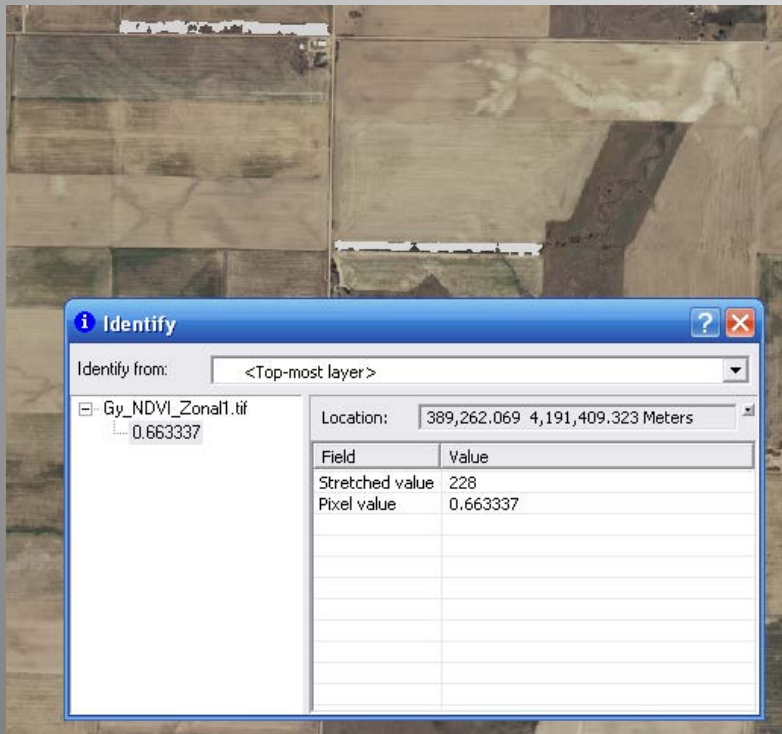**Mean texture value for this windbreak = 53.65**

Normalized Difference Vegetation Index
NDVI is a measure of amount and vigor of vegetation using reflective spectral values of imagery

NDVI value ranges from 0.0 to 1.0

High NDVI = Good Vegetation Health = Good WB condition
Lower NDVI = Poor Vegetation Health = Poor WB condition

Ground Truth Information

- Final assessment based on ground truth Information

- 12% of the windbreaks were visited to collect ground truth information

County	No of WB	GT WB
Gray	196	32
Haskell	22	4
Seward	29	3
Clark	166	24
Ford	355	43
Hodgeman	109	21
Meade	239	17
Total	**1116**	114

25% – 38% of the time ground truthing correlated to remote sensing condition

Condition Assessment

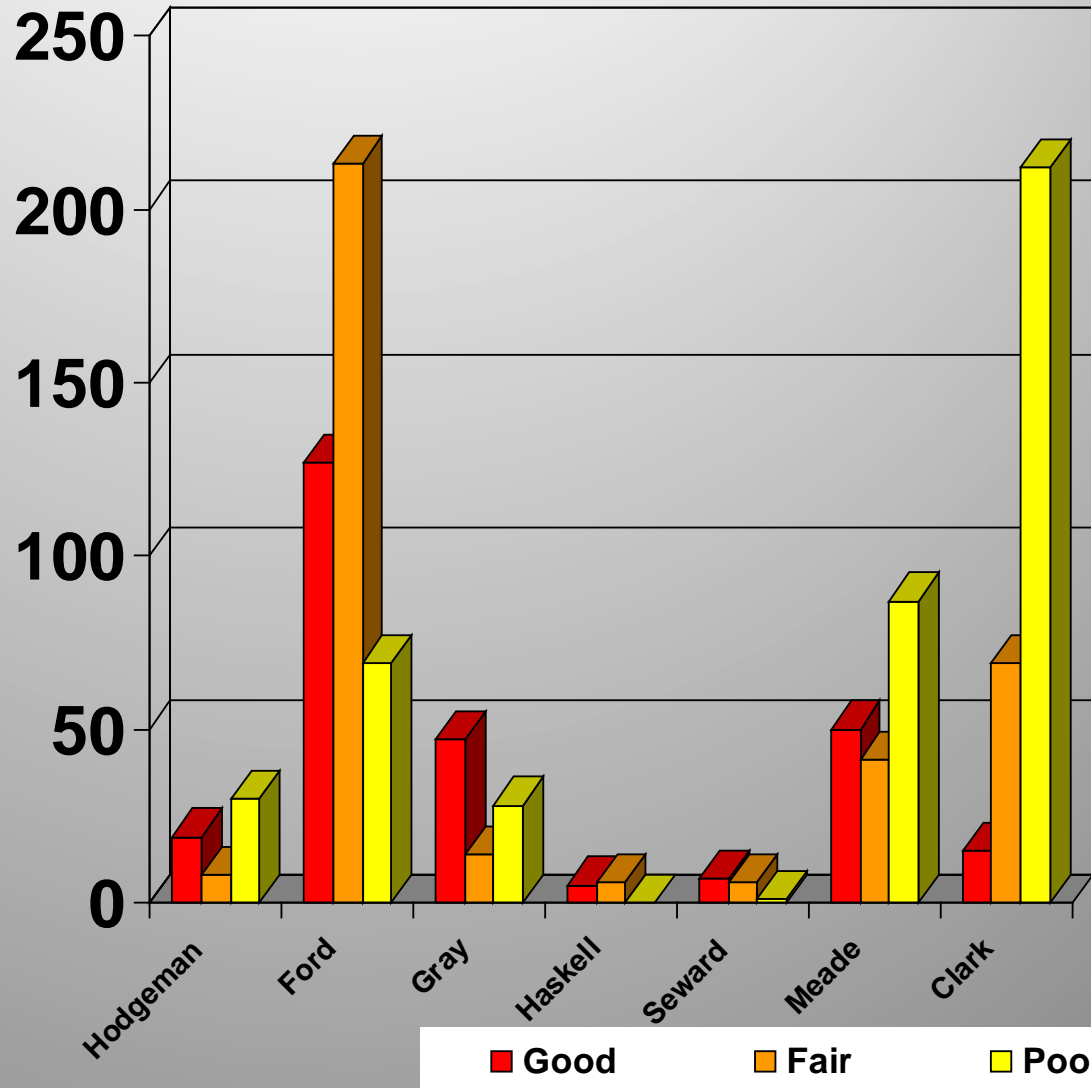| County	Condition classes								
	Good			Fair			Poor		
	No	Acres	Hectares	No	Acres	Hectares	No	Acres	Hectares
Gray	77	117.291	47.4660	41	34.77	14.07	78	70.490	28.526
Haskell	15	12.511	5.0630	7	14.404	5.829	0	0	0
Seward	20	17.442	7.058	7	5.903	2.389	2	2.824	1.142
Clark	14	37.414	15.141	43	168.754	68.2926	109	522.647	211.508
Ford	110	313.1	126.7	185	528.6	213.9	60	170.2	68.9
Hodgeman	40	45.6791	18.4856	21	19.121	7.7380	48	75.737	30.650
Meade	79	124.045	50.199	54	101.0848	40.9076	106	215.321	87.1776
Total	**355**	**667.4821**	**270.1126**	**358**	872.6368	**353.1262**	**403**	**1057.219**	**427.9036**

Condition Assessment

Area in Hectares

27% Good Condition

33% Fair Condition

40% Poor Condition

Clark County
Condition Assessment

14 Good – 37 AC, 15 HA

43 Fair – 168 AC, 68 HA

109 Poor – 523 AC, 211 HA

Poor Condition
Fair Condition
Good Condition
County Boundary
NAIP Image

Application, Measuring Success & Changes to Project Methodology

❑ Obtained landowner parcel/contact information – County Assessors Offices

❑ County Conservation Districts direct mail letters to landowners with WB in poor condition for Cooperative Conservation Partnership Initiative(CCPI) Environmental Quality Incentives Program (EQIP) – (April 2011)

❑ In 2011 over 50 applications for windbreak renovation were received in the project area, none in previous yrs.

❑ Incorporation of LIDAR (Light Detection and Ranging) into remote sensing application (Smoky Hill Region)

❑ Since 2010 - 98 CCPI contracts for $358,651

Status of LiDAR in Kansas
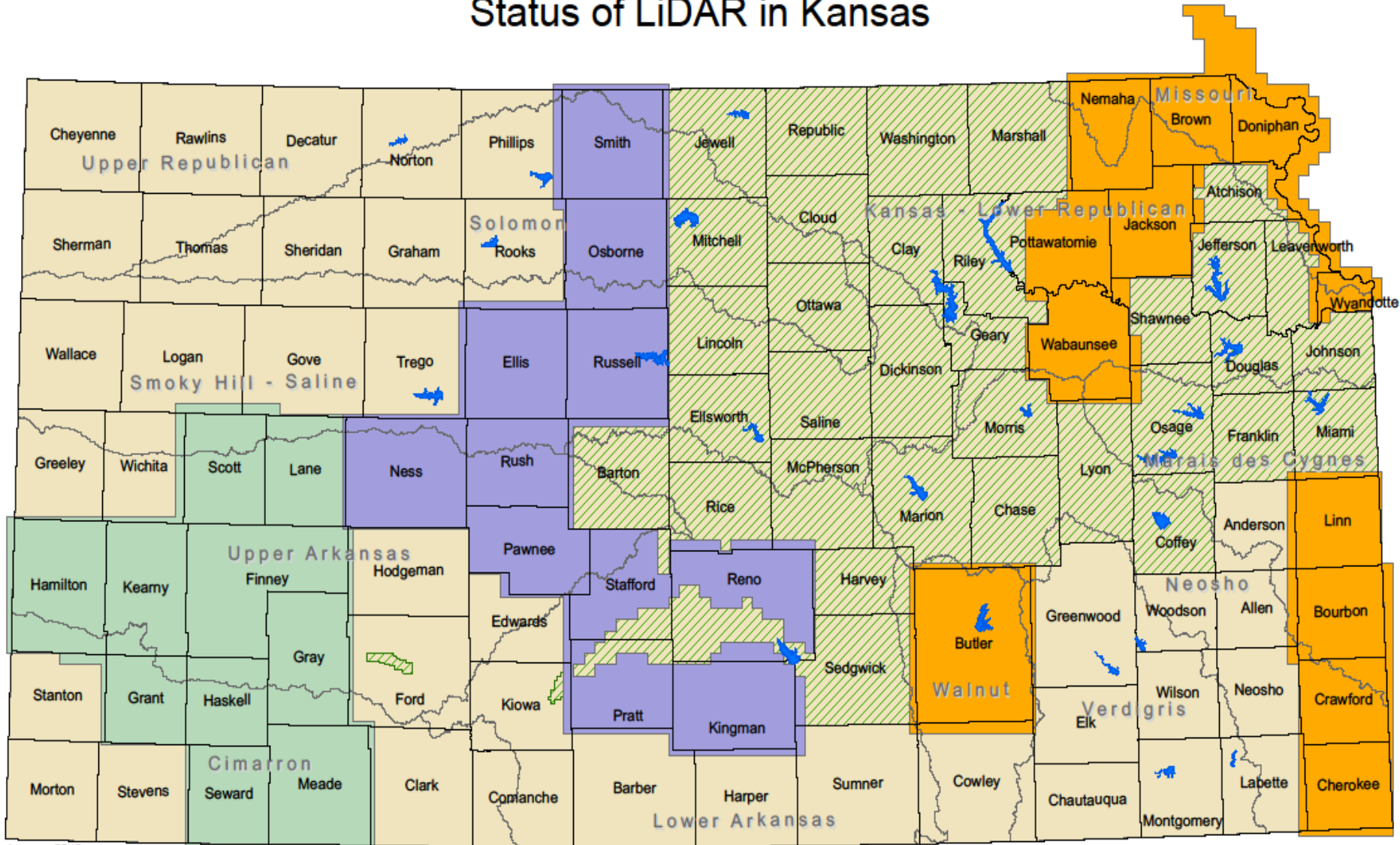
FY2012 Project Area (28,446 SqMi)

- Area 1 (8,793.4 SqMi)
- Area 2 (9,932.4 SqMi)
- Area 3 (9,720.1 SqMi)
- Underway/Completed

January 2012