Session on Land Remote Sensing: User Requirements and Cost Drivers for Landsat

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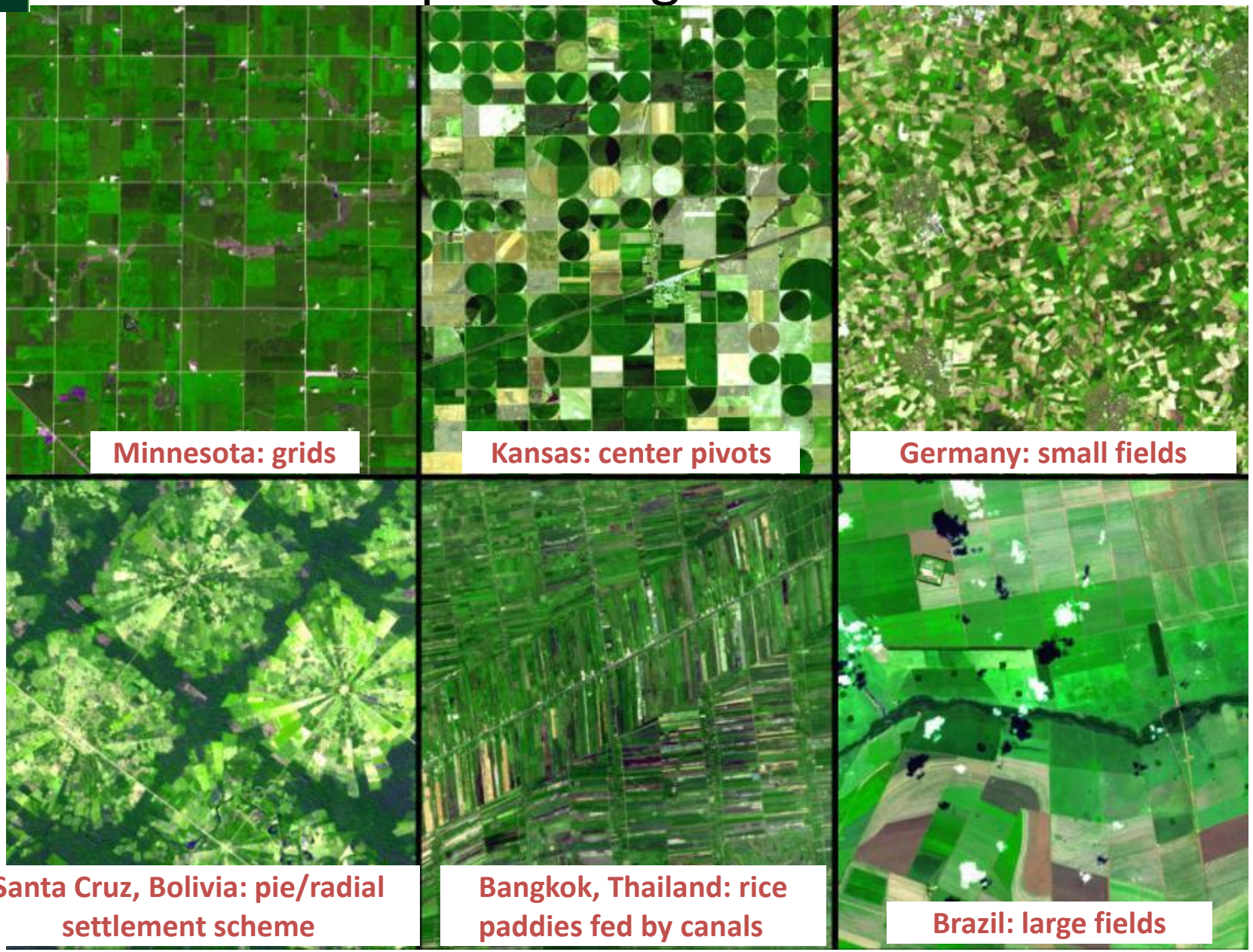
Jeff Bailey
USDA National Agricultural Statistics Service
jeff.bailey@nass.usda.gov
703-877-8000

USDA uses remote sensing for many operational activities

- Disaster Response and Recovery
- Compliance (Crops to Forest)
- Monitoring US and Global Agricultural Production
- Forest Monitoring (Health and Inventory)
- Forest Carbon Stocks and Fluxes
- Burned Area Emergency Response (BAER)
- Conservation Programs
- Pest Management
- Mapping




Crop Planting Patterns



Source: NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team

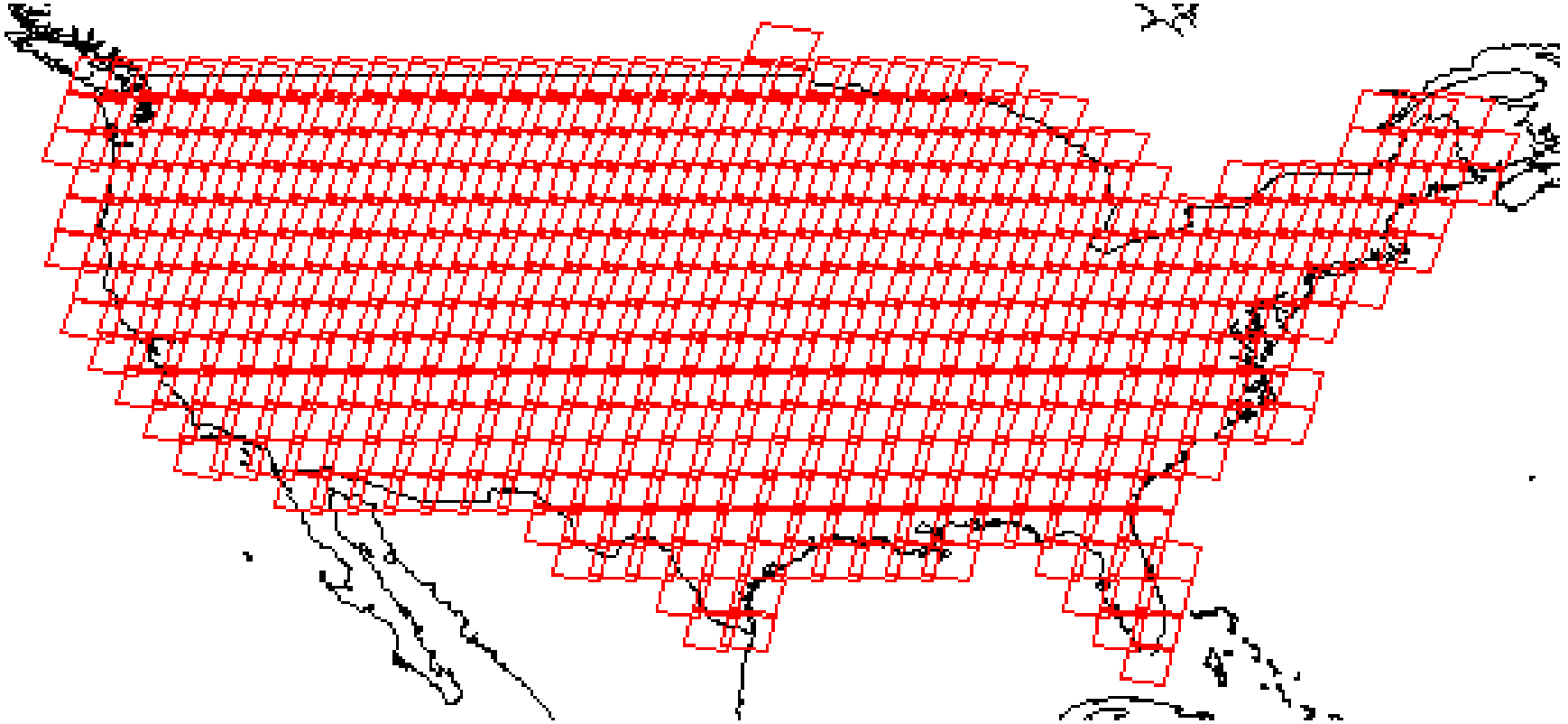
Agriculture's Interrelated Policy and Program Considerations that are Informed by Remote Sensing

- Commodity programs
- Conservation programs
- Agricultural trade
- Rural development
- Agricultural research, education, and extension
- Forestry
- Biofuels
- Sustainable Agriculture
- Disaster programs
- Wildland fire
- Spread of plant pests and diseases

- Carbon Markets
- Environment
- Climate change
- Trade Policy
- Access to food by poorest consumers in poorest countries
- Dealing with longer-term scarcity concerns:
  - Land availability
  - Water
  - Food production inputs, especially energy
- Watershed protection and hydrologic studies

Focus on statistics/facts not forecasting

USDA “Wall to Wall “ & “Year-Round” Crop Monitoring/Mapping/Compliance



NRCS Natural Resources Conservation Service

RMA

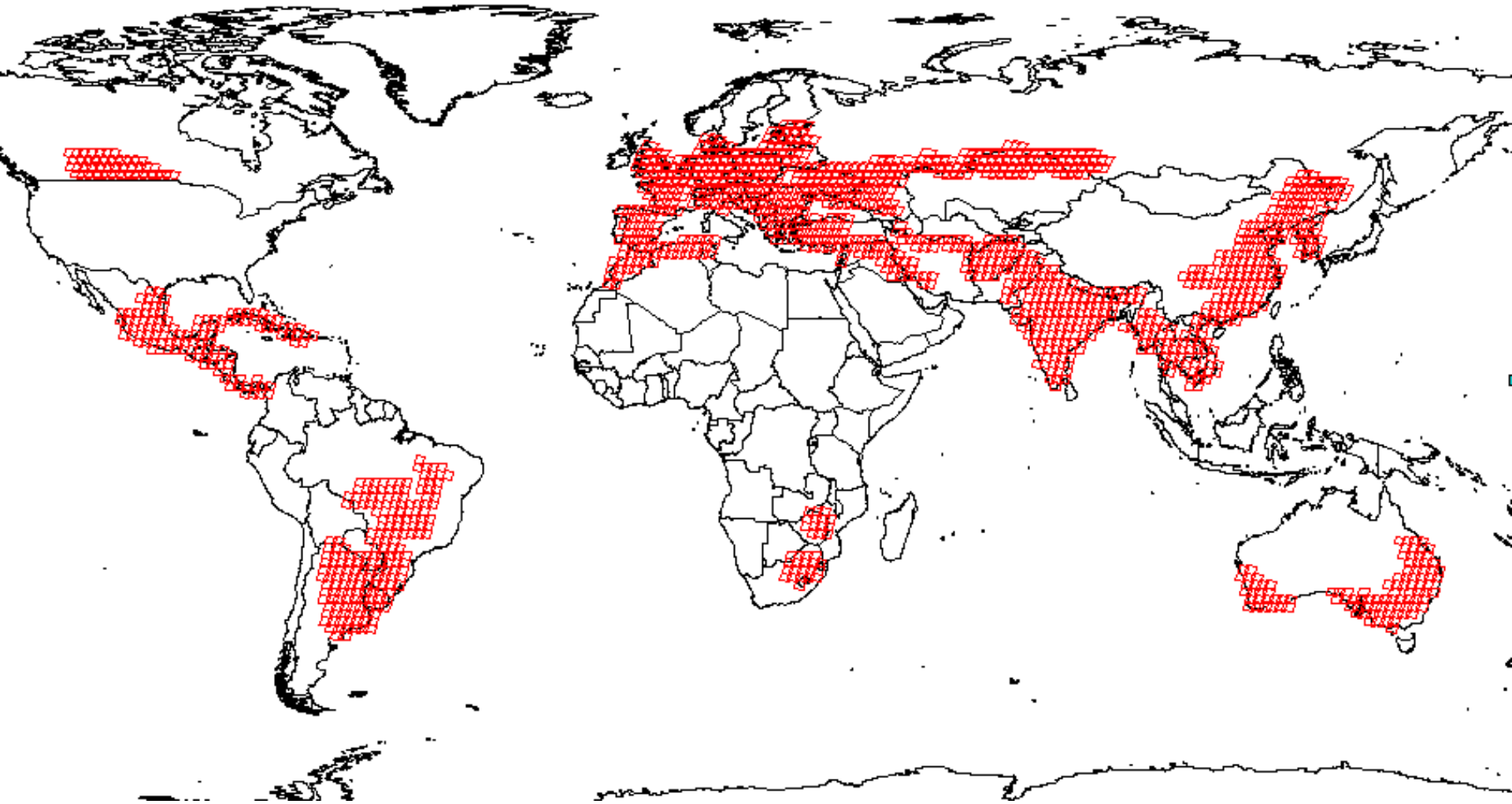
FSA FARM SERVICE AGENCY

NASS

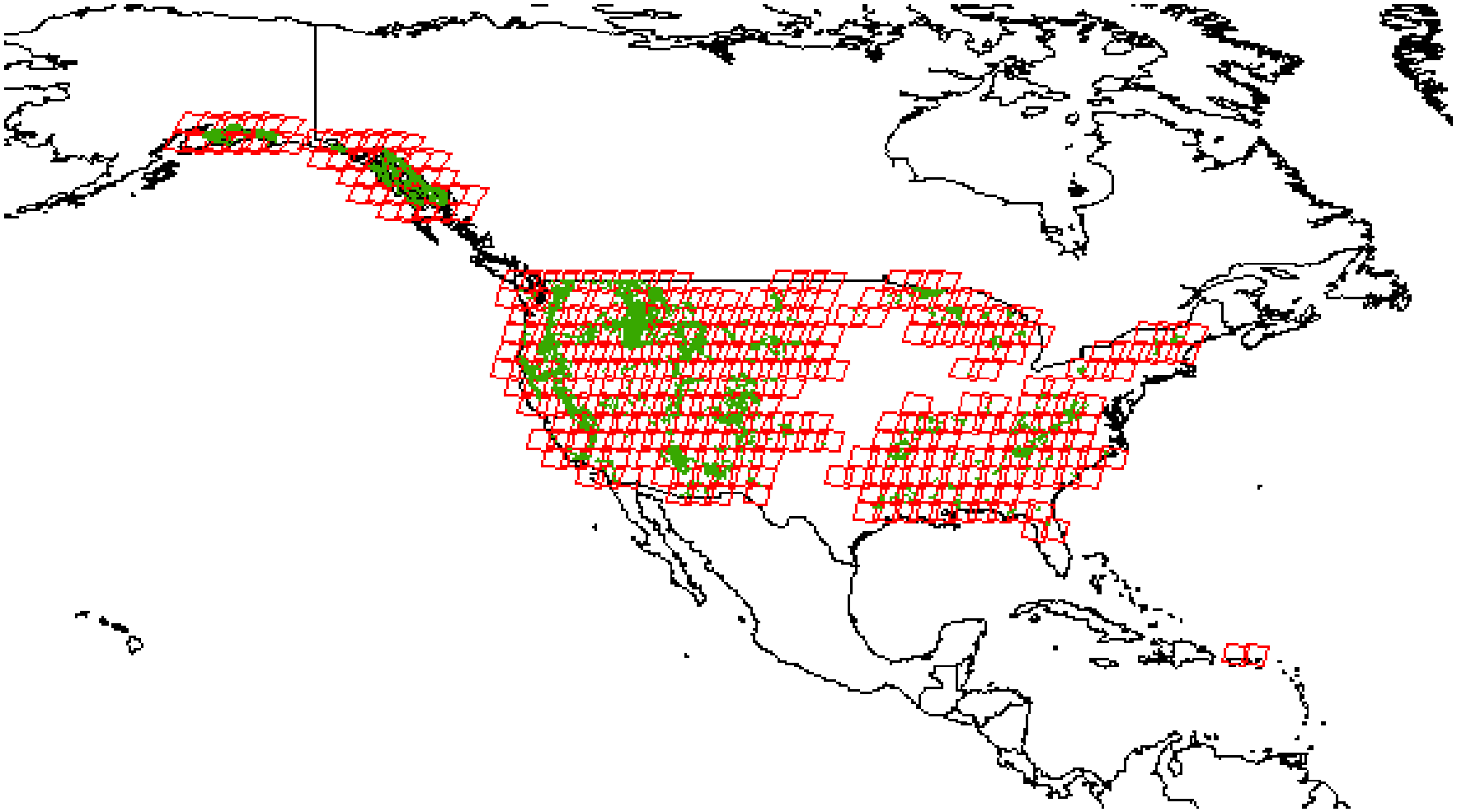
APHIS

= Landsat WRS

Foreign Ag Service Crop Monitoring



Forest Service Lands

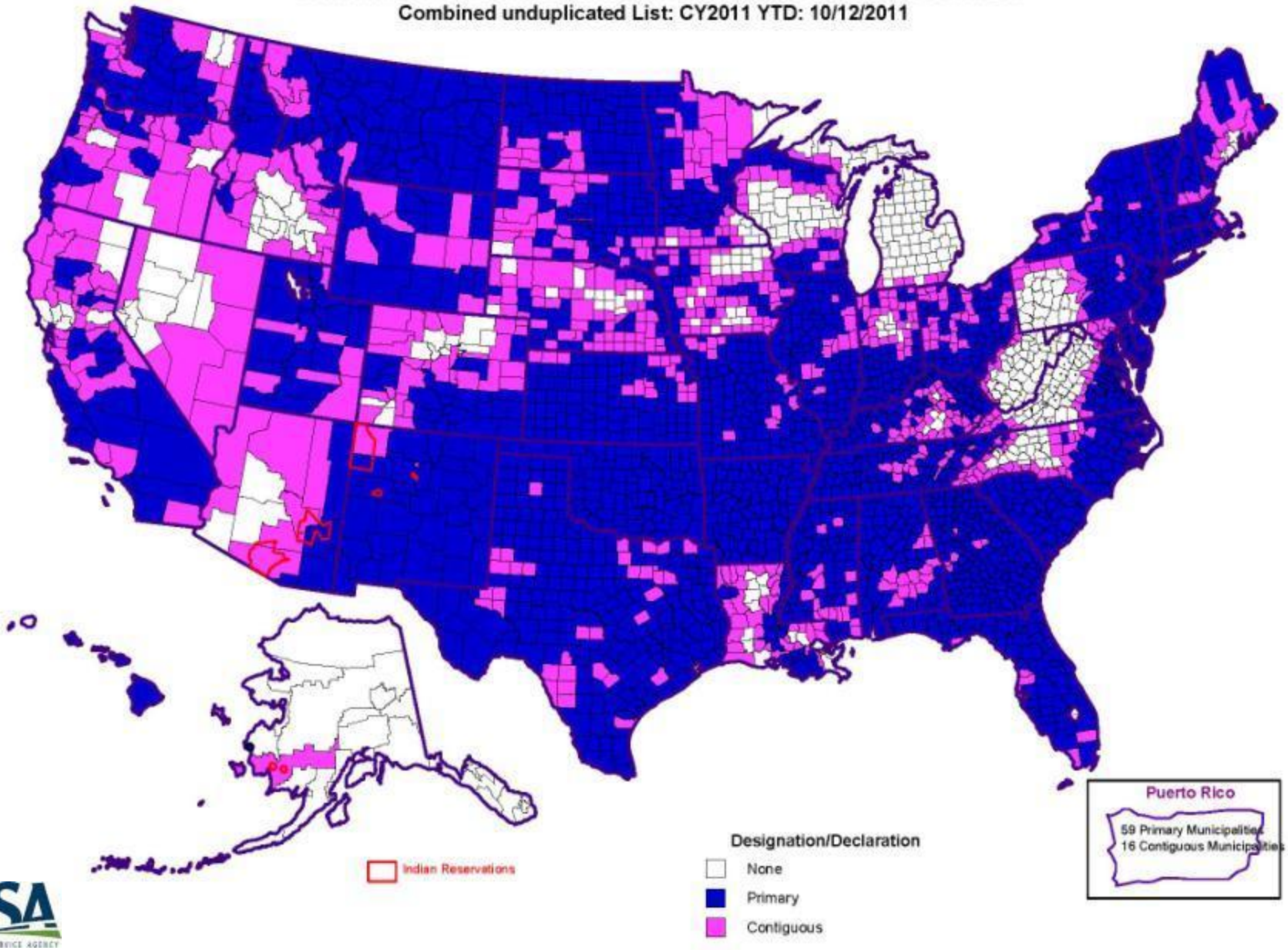


FS requirement includes all US forest cover.

USDA

DISASTER DESIGNATIONS - CY2011

Secretarial & Presidential Disasters PRIMARY & CONTIGUOUS COUNTIES:
Combined unduplicated List: CY2011 YTD: 10/12/2011



FSA
FARM SERVICE AGENCY

USDA Current and Future Land Imaging Requirements

- USDA prioritizes improved temporal over spatial/spectral resolution
  - Lack of image acquisitions during key parts of the growing season
  - 16 day revisits does not meet USDA's diverse mission needs
    - i.e., cloud cover/atmospheric contamination during the growing season

Key Point

USDA Current and Future Land Imaging Requirements

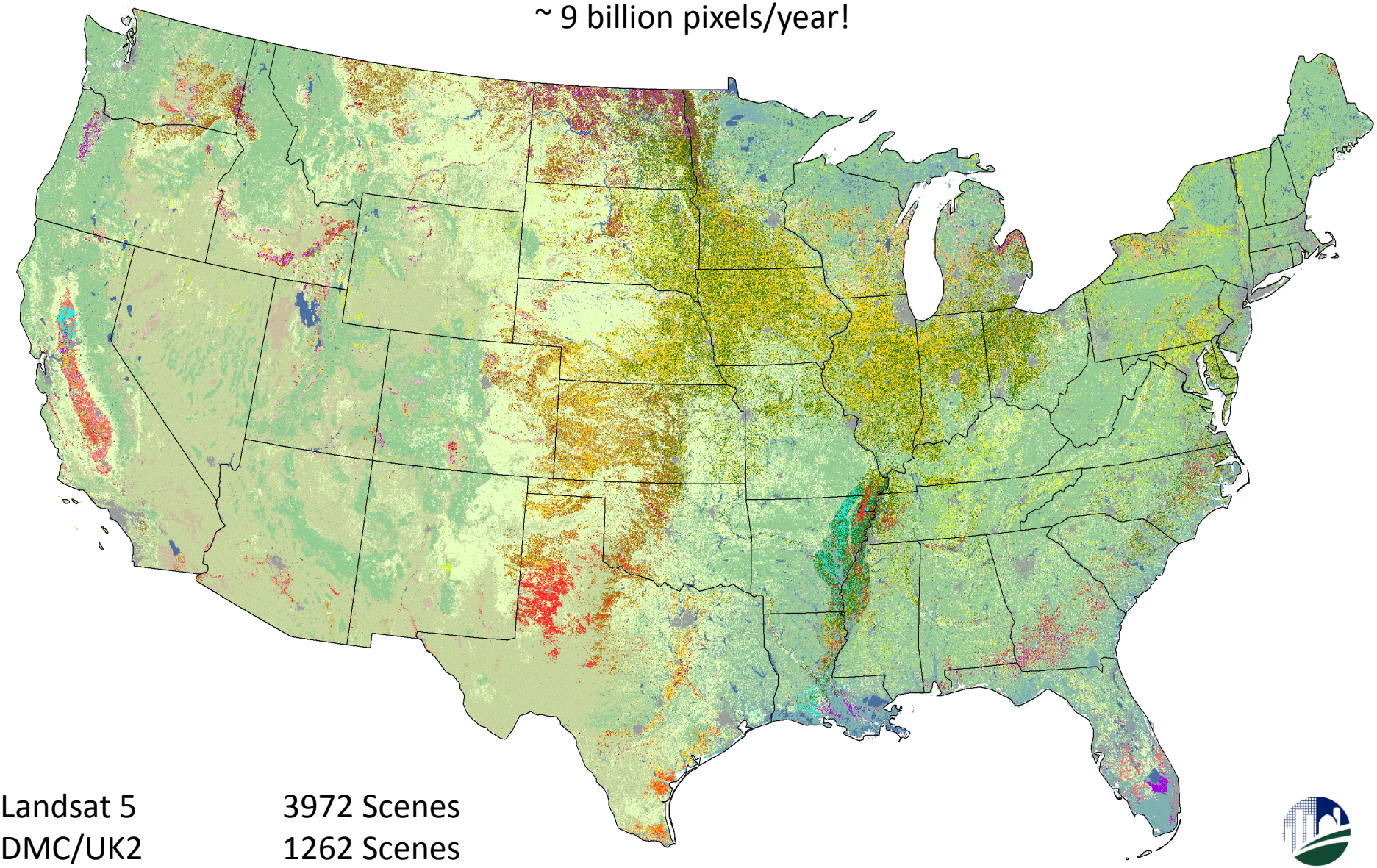
- Reliable sources of time series imagery
  - Change detection and continuous vegetation monitoring
- Timely actionable information
  - High temporal repeat cycle (2-4 days)
  - Additional spectral resolution (upcoming AgSat discussion)
  - Low data latency
  - Imagery ready to use (orthorectification)
- Redundancy and alternative methods
  - Create an operational US Space Constellation for Land Remote Sensing

USDA Current and Future Land Imaging Requirements

- USDA needs an operational mid-resolution US Space Constellation
  - Since 2004 USDA has outsourced imagery procurement to augment needs
    - India, England, and Spain (i.e., Resourcesat & DMC)
    - Risk/vulnerability using imagery generated from foreign countries/governments
- Upcoming LDCM will provide USDA no better coverage than 2011
- Uncertainty on operational availability of European Space Agency Sentinel-2 ability to augment USDA's needs
  - Process not in place to facilitate rapid transmittal of imagery to USDA
  - Cost uncertainty
- USDA will continue to rely on foreign space based assets until US has an operational mid-resolution US Space Constellation

2008 – 2011 National Cropland Data Layers

~ 9 billion pixels/year!



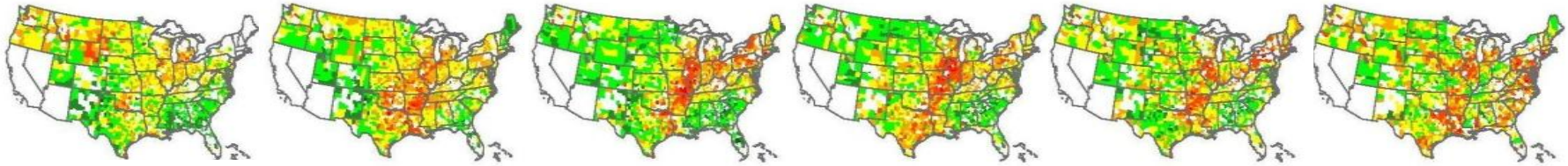
Landsat 5 3972 Scenes
DMC/UK2 1262 Scenes
5234 Total

NASS

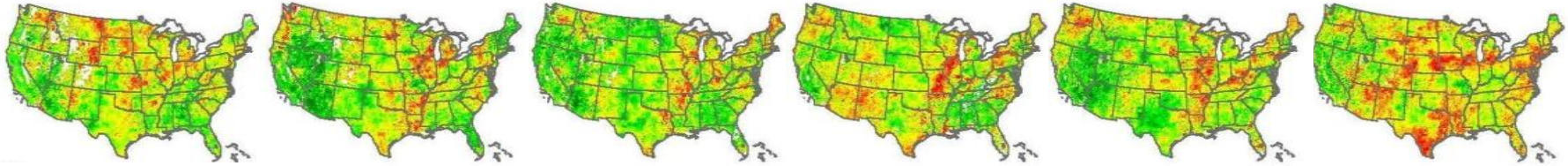
Comparisons with NASS Datasets

NASS sub-soil SM anomalies

NASS top-soil SM anomalies



Evaporative Stress Index



APRIL MAY JUNE JULY AUGUST SEPTEMBER

Continental scaling from GOES Thermal IR to Landsat to separate stress behavior in corn and soybeans

USDA Supports…
Future Land Imaging Recommendations

- Recommendation #1: The U.S. must *commit* to continue the collection of moderate resolution land imagery.
- Recommendation #2: The U.S. should establish and maintain a core operational capability to collect moderate-resolution land imagery through the procurement and launch of a *series* of U.S. owned satellites.
- Recommendation #3: The U.S. should *establish* the National Land Imaging Program, hosted and managed by the Department of the Interior, to meet U.S. civil land imaging needs.

August 2007

USDA Request: Increase Temporal and Spectral Resolution and Lower Costs

- Increase Swath Width
  - Increase to 15-20 degrees off nadir to move to a 300-500km swath rather than the current 183km Landsat swath
    - Assuming same orbit, increased swath increases temporal resolution and increases usability for large area monitoring
- Not all sensors need full on-board calibration
  - Build AgSat that provides additional spectral and temporal resolution that does not have the calibration of Landsat
- Speed up satellite development cycle
  - Build multiple platforms simultaneously
  - Maintain a spare in case of failure and improve temporal coverage
- Unlikely that USDA will invest time or capital in developing operational monitoring programs if the current state of uncertainty and potential for data gaps persists

AgSat Requirements

- Temporal resolution: < 7 days, 5 day or better ideal to capture critical crop development stages, tillage operations
- Spatial Resolution
  - 60 m maximal in Visible through Short Wave IR
  - 100 m Thermal IR
  - Ideal: 20 m Visible/Short Wave IR, 60 m Thermal IR
- Nadir looking
  - Swath width constrained to a maximum 20° off-nadir view angle

AgSat Requirements

- Quantization 12 bits
- Signal-to-Noise Ratio (SNR) requirements: >250
- Narrower MODIS/ASTER-type bands in Short Wave IR to discriminate cellulose absorption:
  - Tillage/residue/carbon monitoring
  - Agricultural greenhouse gas and soil erosion/ water quality monitoring/ modeling
  - Rangeland health/ soil quality monitoring
  - Grassland fire hazard mapping and monitoring
  - Capability to measure important new climate variables
- 72-hour max turnaround time from acquisition to end user

AgSat Specs

Band number	Band center and bandpass (nm)	Region	Parameter	Indices	Heritage
1	443 (433–453)	Blue	Coastal/Aerosols		LDCM
2	480 (470–490)	Blue	Aerosols	EVI	Landsat TM
3	531 (526–536)	Green	Xanthophyll	PRI	MODIS
4	550 (540–560)	Green	Chlorophyll	GNDVI, Red Edge indices	Landsat TM
5	570 (565–575)	Green	Xanthophyll	PRI	MODIS
6	670 (660–680)	Red	Vegetation cover	EVI, NDVI	Landsat TM
7	705 (695.5–712.5)	Red edge	Chlorophyll	Red Edge indices	Sentinel-2
8	740 (732.5–747.5)	Red edge	Chlorophyll	Red Edge indices	Sentinel-2
9	783 (773–793)	NIR	Chlorophyll, biomass, atmospheric correction	Red Edge indices	Sentinel-2
10	850 (840–860)	NIR	Vegetation cover	EVI, NDVI, NDWI	Landsat TM
11	940 (950–960)	NIR	Water vapor		Sentinel-2
12	1375 (1360–1390)	SWIR	Cirrus clouds		LDCM
13	1650 (1625–1675)	SWIR	Vegetation water content	NDWI	Landsat TM
14	2040 (2025–2055)	SWIR	Cellulose	CAI	New band
15	2100 (2080–2120)	SWIR	Cellulose	CAI	New band
16	2210 (2190–2230)	SWIR	Cellulose	CAI	New band
17	10.8 (10.3–11.3) µm	TIR	ET, Vegetation stress	DisALEXI	LDCM
18	12.0 (11.5–12.5) µm	TIR	ET, Vegetation stress	DisALEXI	LDCM

USDA Requirements Summary

- Operational requirements
  - Monitor National Resources - Ag & Forestry
- #1 priority improve temporal capacity
  - Consider US Space Constellation for Land Remote Sensing
  - One-off Landsats force USDA to off-shore image collections
- #2 improve spectral capacity
  - AgSat spectral bands provide carbon/tillage/residue monitoring
    - Consider red-edge and cellulosic bands as ag requirements
    - Relaxed calibration requirements

AgSat References

- Serbin G., Daughtry C.S.T., Hunt E.R., Jr., McCarty G.W., Doraiswamy P.C., Brown D.J. (2009) Effect of soil mineralogy, organic matter, and water content on continuum-removal spectral indices for remote sensing of crop residue. Soil Science Society of America Journal 73:1545-1558.
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- Assessment of Spectral Indices for Crop Residue Cover Estimation. 2010 IEEE International Geoscience & Remote Sensing Symposium (IGARSS) 2010, Honolulu, HI. July 23-31, 2010. 1827-1830.