The Utility and Limitations of Remote Sensing in Land Use Change Detection and Conservation Planning

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UIC

Presentation to:
US Environmental Protection Agency
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UIC - Key Research Efforts

- Biofuels/Ethanol Life Cycle Analysis
  - Impact of sustainable production practices on life cycle emissions
  - Member, Expert Working Group, California Low Carbon Fuel Standard Development
- Collaboration with Argonne National Laboratory to inform GREET Biofuels and Ag Feedstock pathway
  - Long term collaboration, 15+ joint papers and publications
- International Ag and Ethanol Feedstock Certification
  - Board Member of International Sustainability and Carbon Certification (ISCC); Biggest certifier of bioproducts under the EU RED
  - Certification methodology development for qualifying US produced biofuels for export to EU and Japan
  - Support development of the GRAS Global Risk Assessment Services Tool
- Sustainable Ag and Pollinator Habitat Work
  - Coordinator, Illinois Monarch Butterfly Initiative
  - US Fish and Wildlife Service Support, National Fish and Wildlife Foundation Grant Recipient
- Urban Air Emissions Impact: EPA MOVES modeling to determine combustion emissions from biofuels blends

Presentation Overview

- Review Recent Publications on:
  - Land Use Expansion – and Error in Analyses
  - Marginal Lands
- Identification of Field Buffers via Remote Sensing
- GRAS Land Use Sustainability Tool
- Emerging Microsats

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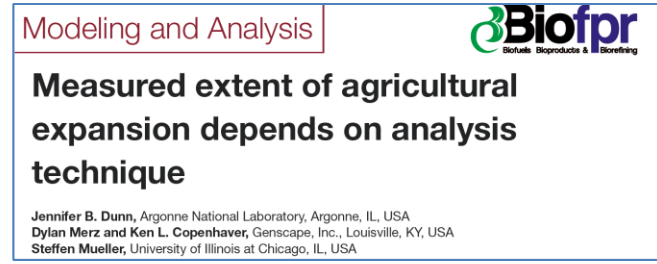
New Publication on Error in Land Use Expansion Studies

New 2017 Study on Remote Sensing Errors in Land Use Analysis


Modeling and Analysis

Biofpr Biofuels Bioproducts & Biorefining

Measured extent of agricultural expansion depends on analysis technique

Jennifer B. Dunn, Argonne National Laboratory, Argonne, IL, USA
Dylan Merz and Ken L. Copenhaver, Genscape, Inc., Louisville, KY, USA
Steffen Mueller, University of Illinois at Chicago, IL, USA

- Some studies assert that ecologically important, carbon-rich natural lands in the United States are losing ground to agriculture.
- We investigate how quantitative assessments of historical land-use change (LUC) to address this concern differ in their conclusions depending on the data set used in 20 counties in the Prairie Pothole Region using:
  - the Cropland Data Layer,
  - a modified Cropland Data Layer dataset,
  - data from the National Agricultural Imagery Program,
  - and in-person ground-truthing.

  We find:
  - The Cropland Data Layer analyses overwhelmingly returned the largest amount of LUC with associated error that limits drawing conclusions from it.
  - Analysis with visual imagery estimated a fraction of this LUC.
  - Clearly, analysis technique drives understanding of the measured extent of LUC; different techniques produce vastly different results that would inform land management policy in strikingly different ways.
  - Best practice guidelines are needed.

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Total Cropland

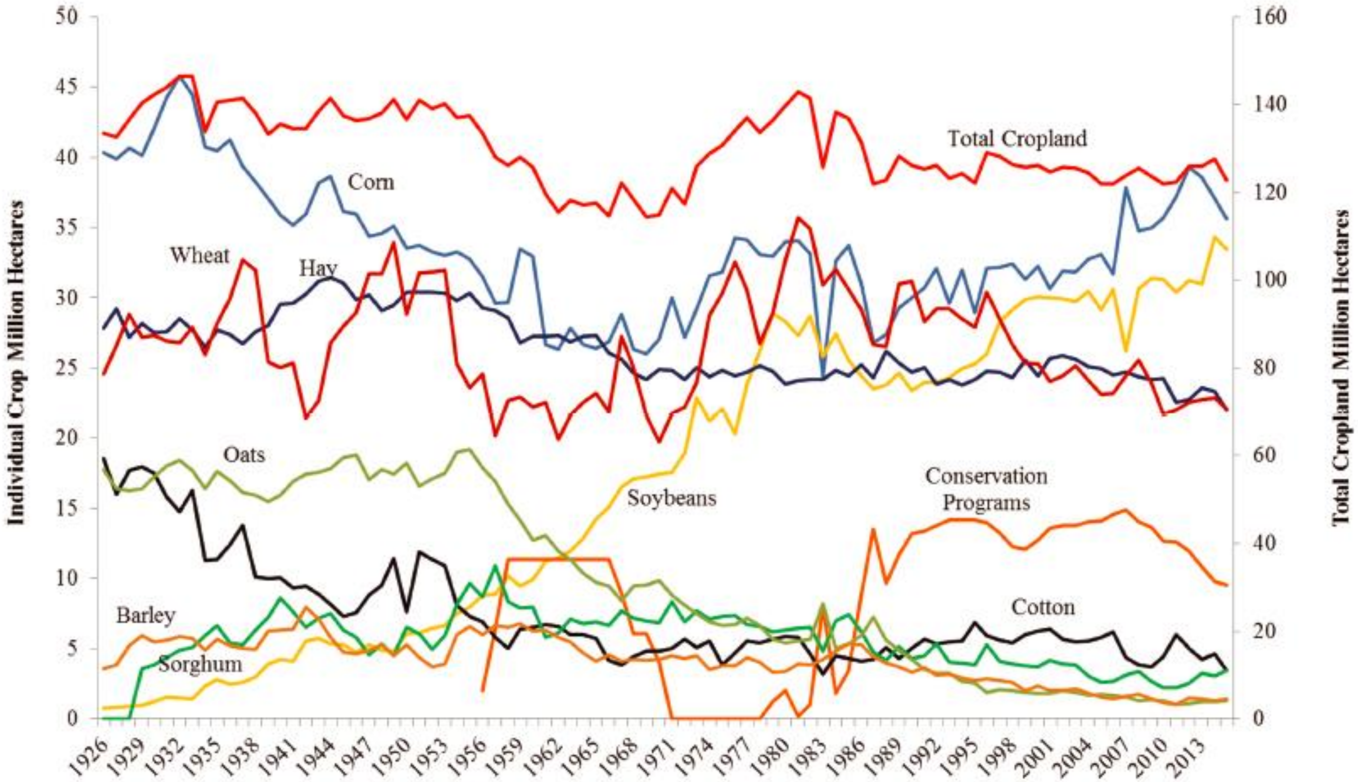

Figure 1. Total cropland hectares and individual crop hectares from 1926 to 2015.[9]

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CDL vs. NAIP vs. Groundtruthing

Photo name: luc-02-Dec-2015-09-10-58.jpg
View to north
Ground truth: Pond
Lat, long: 47.96352 -96.6211

Land Use Change Assessment with Different Methods

Table 1. Comparison of results from this study (2006 to 2014), Lark *et al.*[4] (2015) (2008-2012), Reitsma *et al.*[15] (2016) (2006-2012) (thousand ha).

	Forest to Cropland				Wetland to Cropland				Wetland and Forest to Cropland	
	This Study			Lark et al.	This Study			Lark et al.	Reitsma et al.	
	NAIP[a]	CDL	Mod-ified CDL	CDL[b]	NAIP	CDL	Mod-ified CDL	CDL[b]	CDL	NAIP
MN[c]	1.7	249	0.02	5.6	0	38	0	10	NA	NA
ND	0.83	222	13	0.44	0.01	25	0	7.4	NA	NA
SD	1.2	94	2.3	0.47	0	47	0	5.1	416	336

[a]Includes forest and grassland that was converted to cropland.
[b]Lark *et al.*[4] describe their modifications to the CDL in the supporting information to their paper. We attempted to replicate this approach, reporting results as 'modified CDL'.
[c]We used 2013 NAIP imagery because 2014 imagery was not available at the time of analysis.

Using the Cropland Data Layer or the Modified Cropland Data Layer (with aggregated classes) produces significantly higher land use change than NAIP and ground truthing

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New Publication on Marginal Lands

Marginal Lands (publ. 12/2016)

Environmental Science & Technology

Article

pubs.acs.org/est

Evaluating the Potential of Marginal Land for Cellulosic Feedstock Production and Carbon Sequestration in the United States

Isaac Emery,[†] Steffen Mueller,[‡] Zhangcai Qin,[§] and Jennifer B. Dunn[*,§]

- Land availability for growing feedstocks at scale is a crucial concern for the bioenergy industry.
- Feedstock production on land not well-suited to growing conventional crops, or marginal land, is often promoted as ideal, although there is a poor understanding of the qualities, quantity, and distribution of marginal lands in the United States.
- We examine the spatial distribution of land complying with several key marginal land definitions at the United States county, agro-ecological zone, and national scales, and compare the ability of both marginal land and land cover data sets to identify regions for feedstock production.
- **We conclude that very few land parcels comply with multiple definitions of marginal land.**

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New Mapping Work on Extent of Agricultural Field Buffers

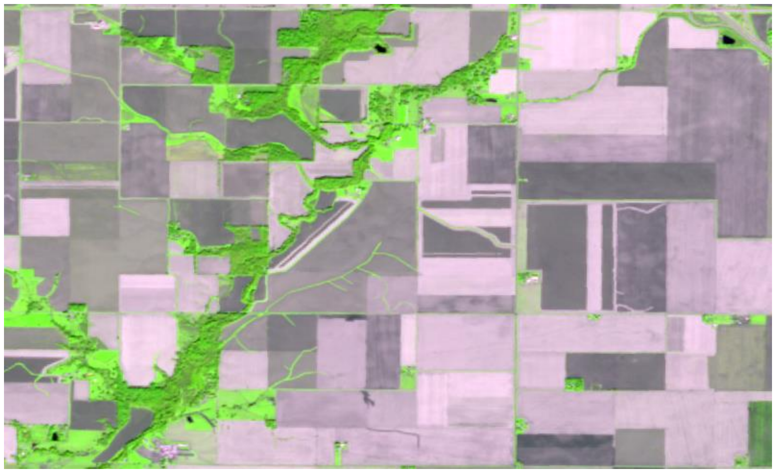
CropGrower

CropGrower

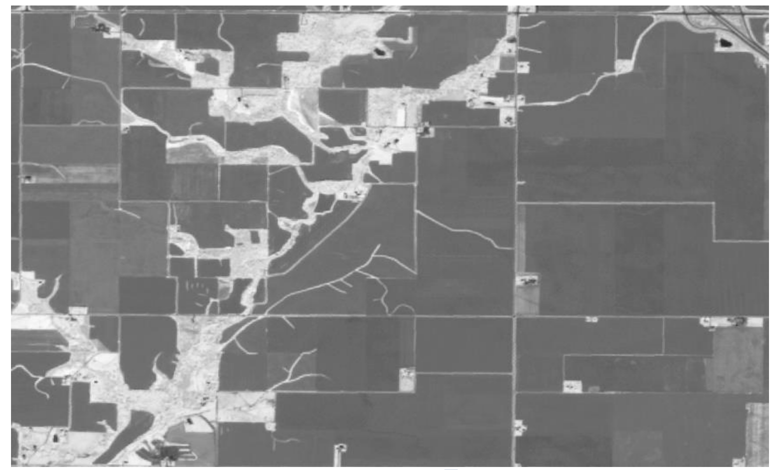
Methodology: Step One

Satellite Imagery Collected in late Spring or Fall
(when grass is growing but crop not on field)

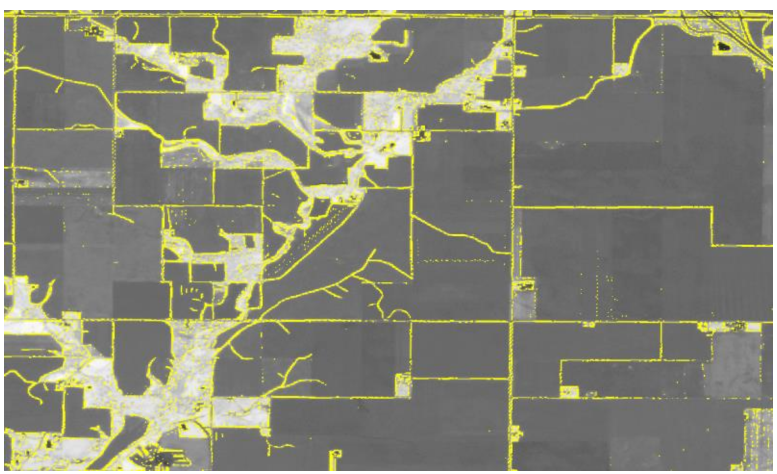
Sentinel-2A 10-meter
Multispectral Satellite Imagery



Create Vegetation Index



Threshold to select only buffers (yellow)



High Pass Edge Detection Filter

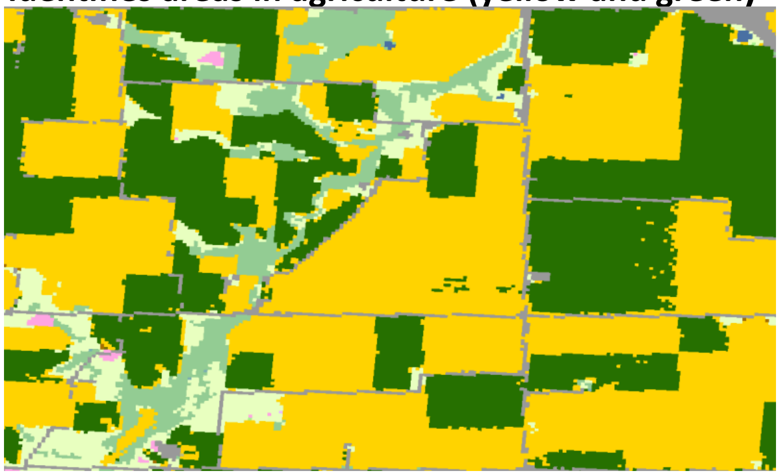
CropGrower

Methodology: Step Two

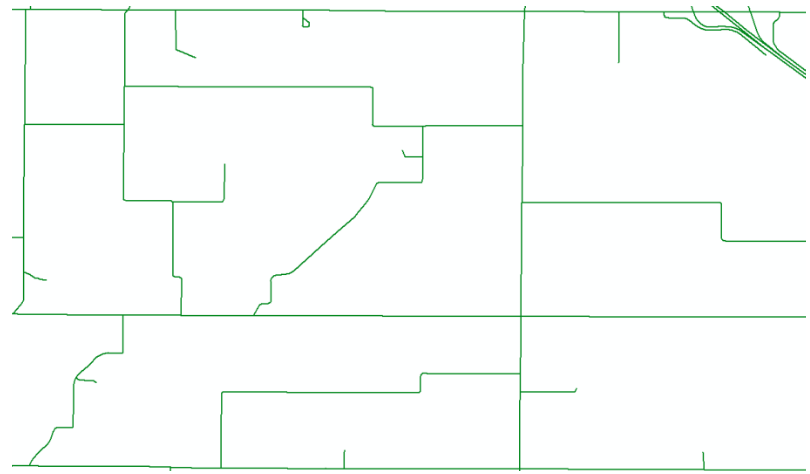
Only analyze buffers "within agricultural land"

2015 USDA Cropland Data Layer

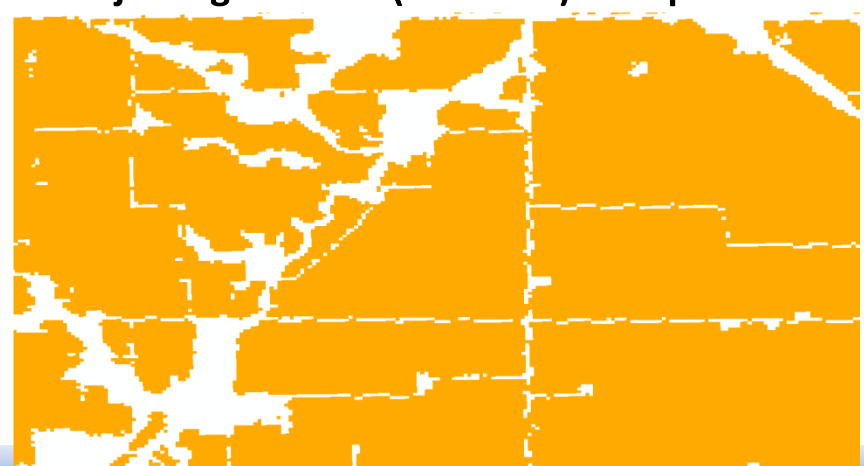
Identifies areas in agriculture (yellow and green)



Roads Layer

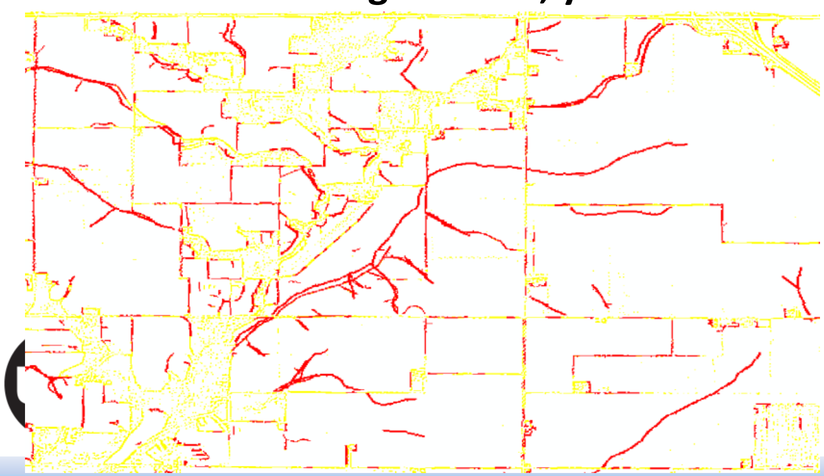


Use just agriculture (no roads) to clip buffers



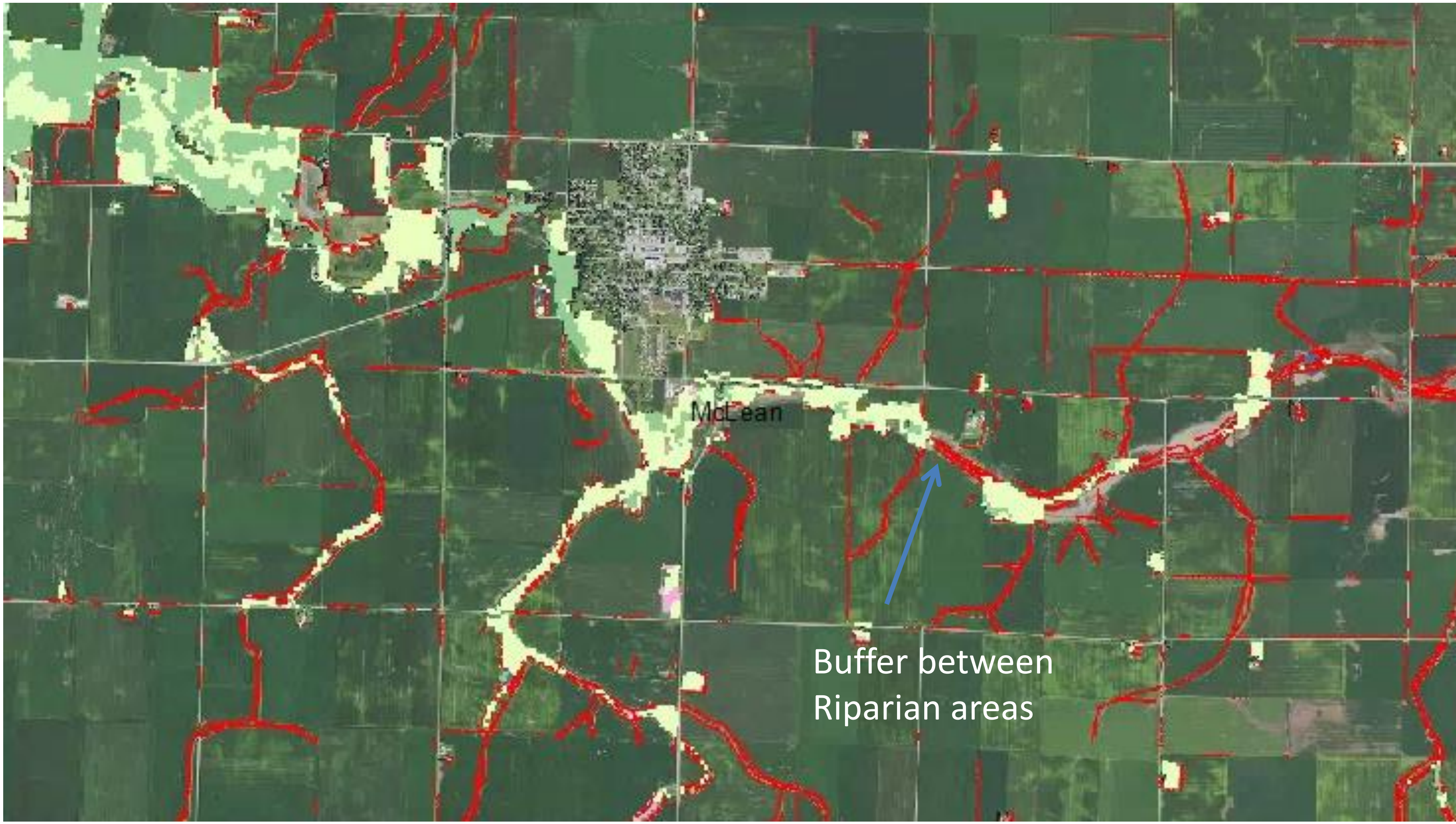
Only analyze buffers identified as agriculture

Red buffers are in agriculture, yellow are not



CropGrower

Application 1: Optimize/Extend Pollinator Pathways



Forested Wetlands   Herbaceous Wetlands

Application 2: Integrate Layers with Existing Software Products

- E.g Agsolver and others
- This is a profit comparison where one field zone was put into pollinator habitat which increased field profitability because it was put into CP42 (Pollinator adder to CRP program) and secondly because of reduced inputs

PROFIT ZONE MANAGER

Webster

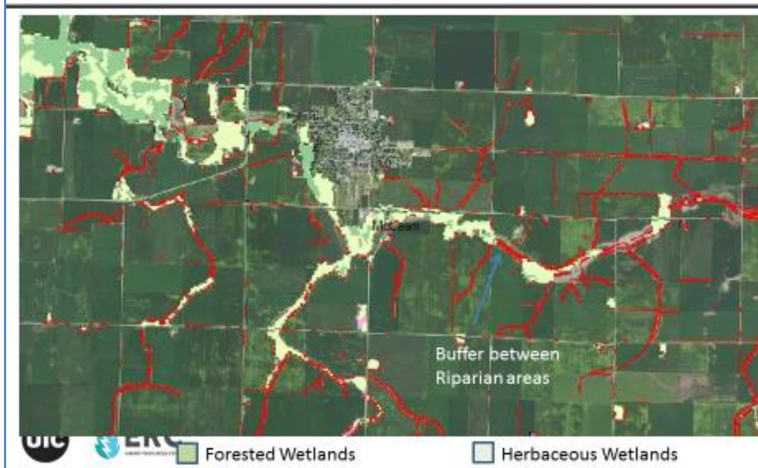
Scenario: Actual Production - 2010

Parameter	Value
Field Acreage	143.3 ac
Average Yield	170.5 bu/ac
Profit	$51.20/acre
ROI	6.4 %

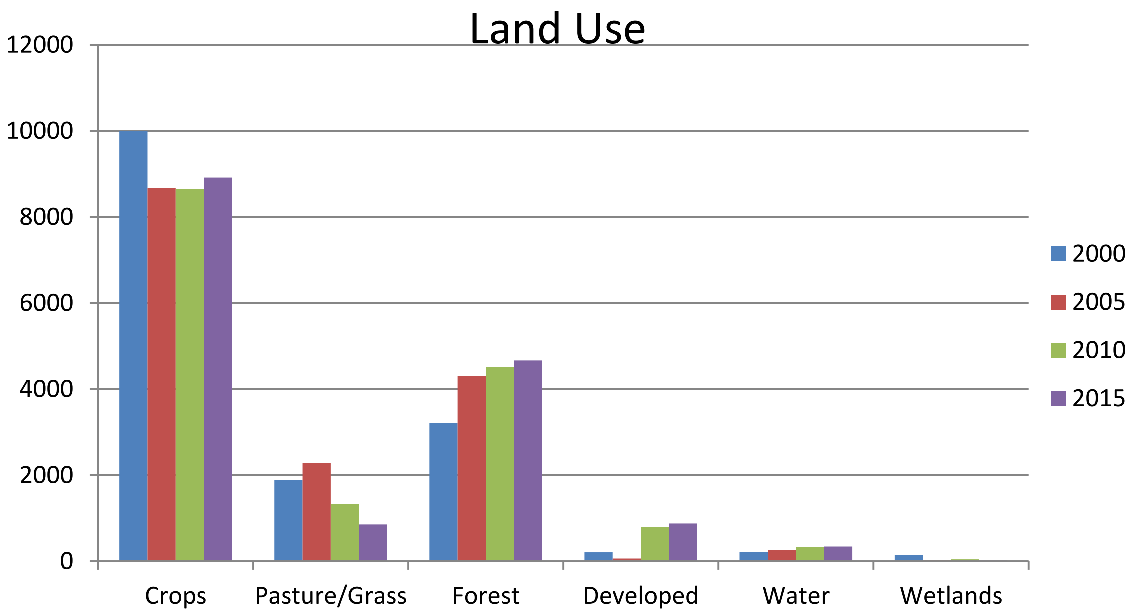
Scenario: Conservation-Final - 2010

Parameter	Value
Field Acreage	143.3 ac
Average Yield	179.2 bu/ac
Profit	$101.64/acre
ROI	13.9 %

Optimize/Extend Pollinator Pathways



Application 3: Local Watershed Analysis



HONEY CREEK UPPER MACOUPIN CREEK

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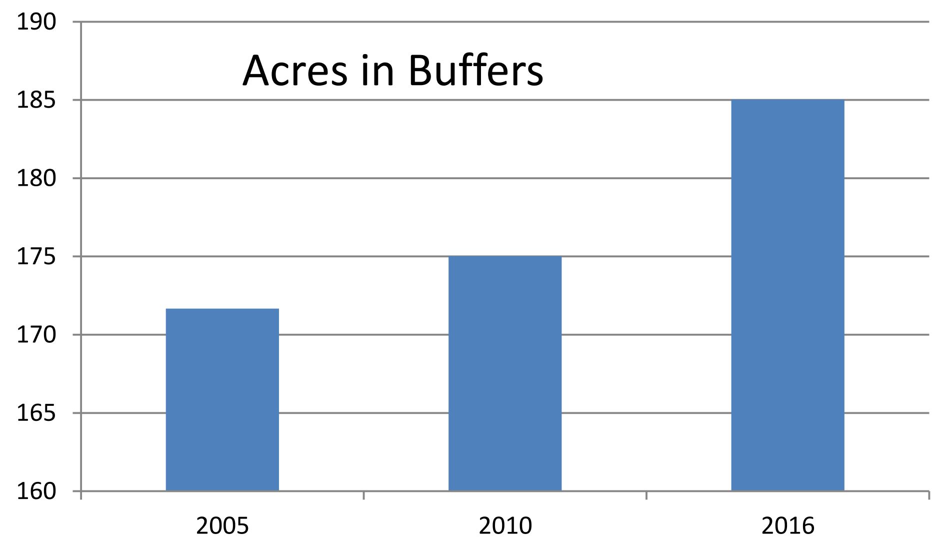
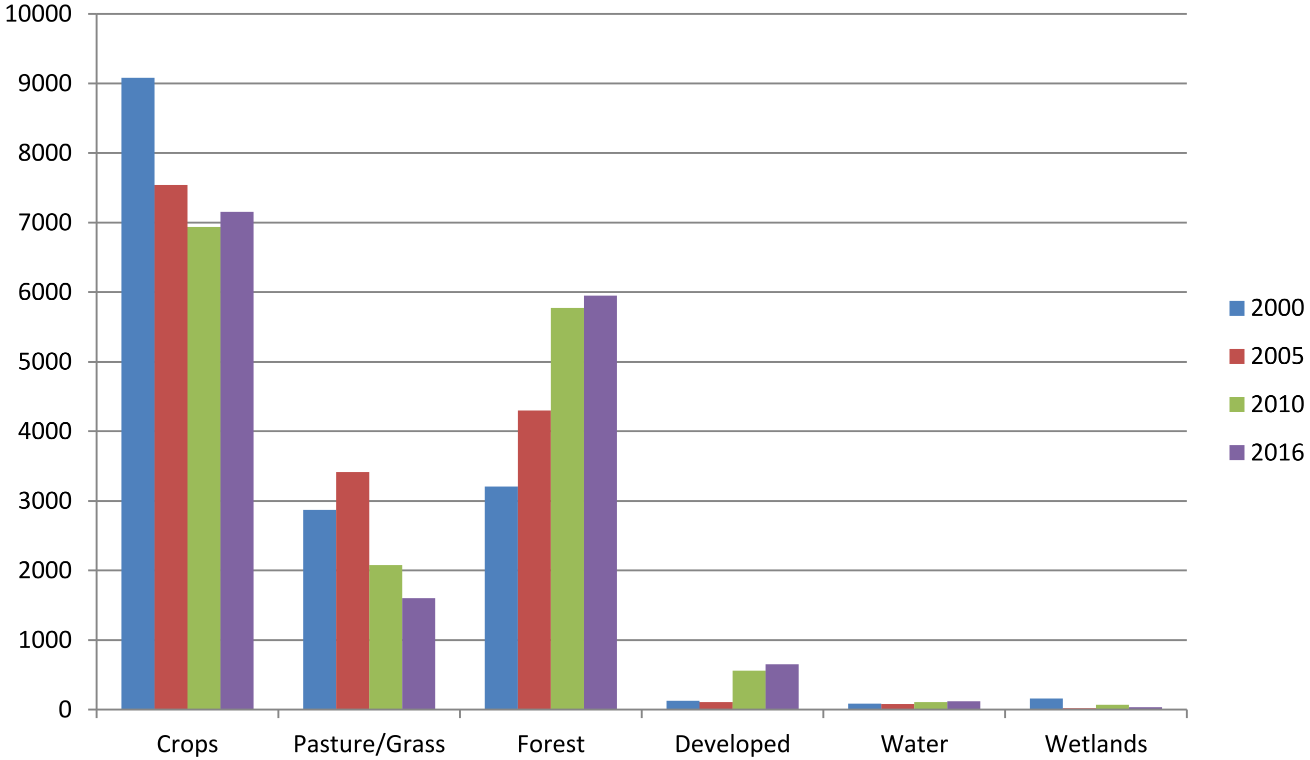


DRY FORK



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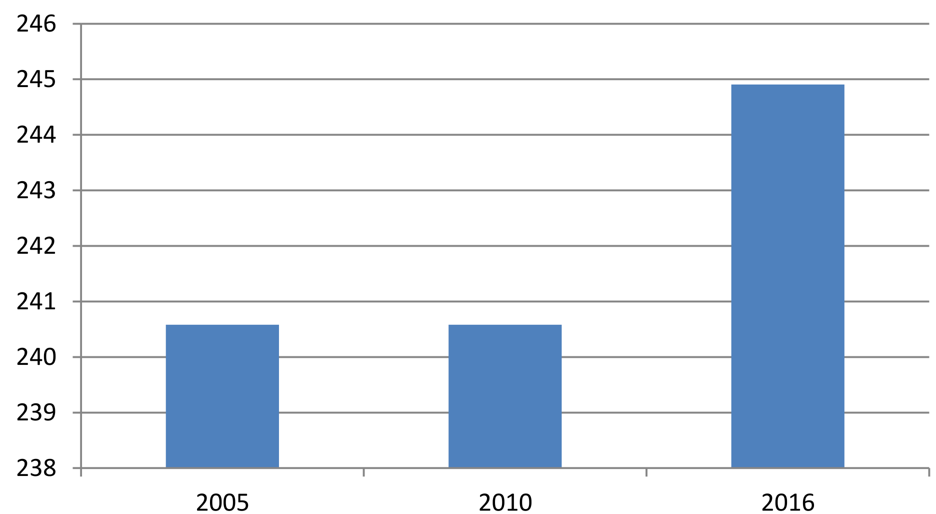
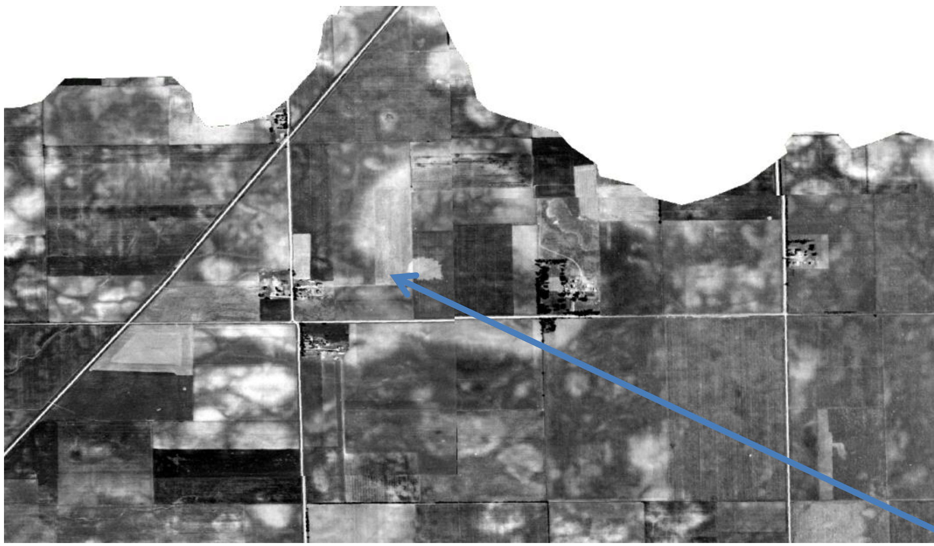


Application 4: Compare Current Buffers to 1940 Aerial Imagery

Only performed for Five Mile Creek

1940 Imagery



2015 Imagery

Essentially, no in-field buffers were in place in 1940.
Smaller field sizes
Time consuming process as 1940 imagery is not geo-referenced

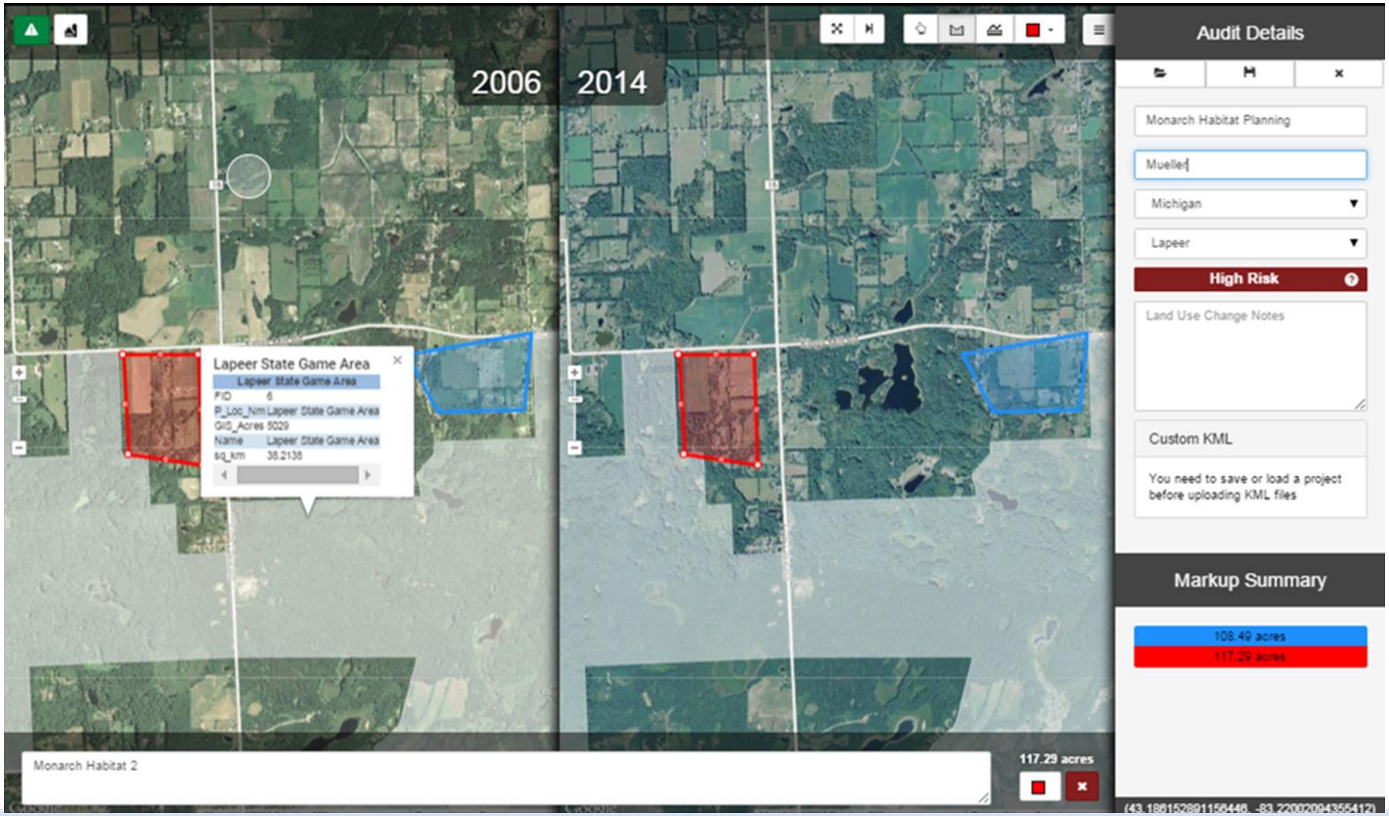
International Sustainability and Carbon Certification (ISCC): Developer of GRAS Land Use Tool

Global Risk Assessment Services

https://www.gras-system.org/

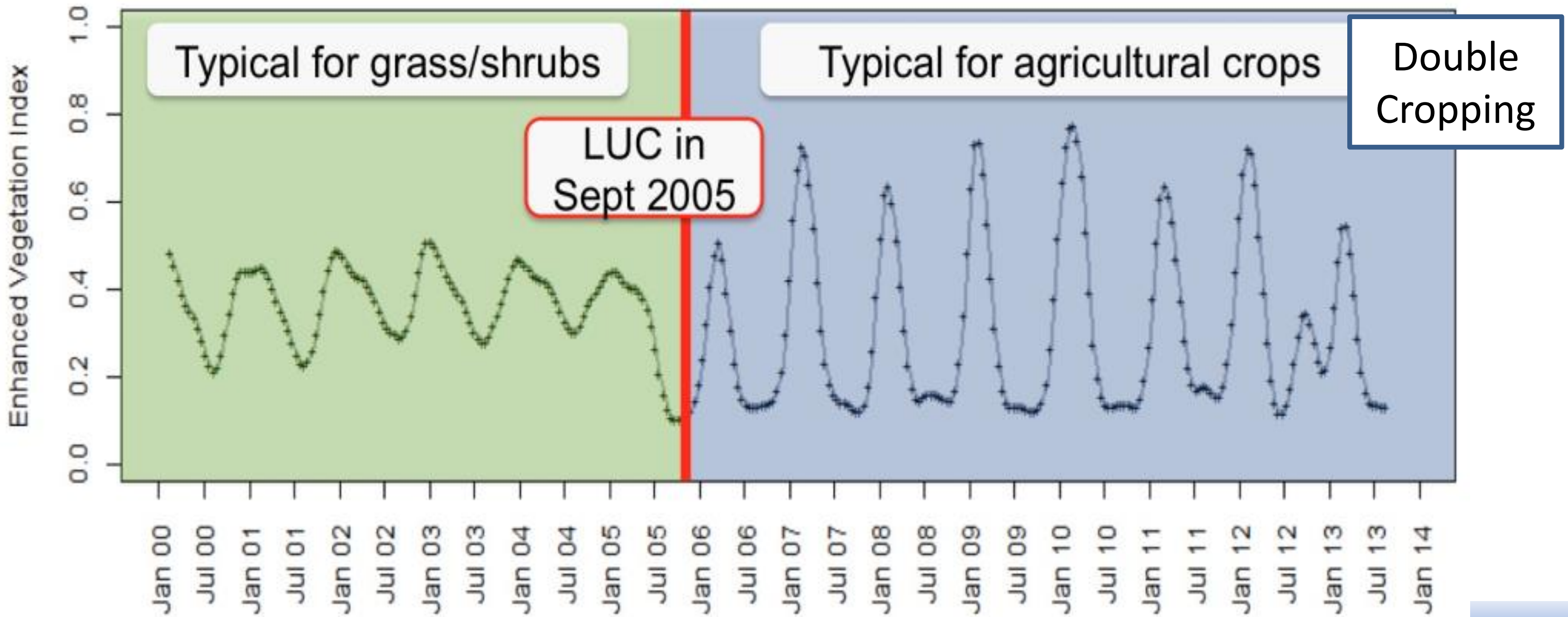
New Software for Sustainability Assessment: Global Risk Assessment Services Tool (GRAS) for United States Domestic LUC Analysis

- Feedstocks are not grown on deforested lands; Verify use of large, mature crop areas
- Applicable for US corn/soy feedstocks
- Use of NAIP Imagery (1-2 m resolution)
- Side by side viewer of pre 2008 and current image for direct comparison
- Overlay protected areas, carbon masks, LUC risk masks



New Software: GRAS Tool for Global Land Use Analysis – Ensure Biofuels Feedstocks Do not come from Deforested Lands

- Particularly applicable for South American Feedstocks (sugarcane, corn soy) and S/E Asia (Palm, etc.)
- Use of MODIS Enhanced Vegetation Index (300 Images) going back to 2000.
- Differentiate among the types of green cover, see the history of the land, assess double cropping and detect LUC.
- Grassland has EVI value of 0.3-0.4. The same would apply for perennial trees such as rain forests but on a higher EVI value of about 0.6. Conversion would appear as a clear change in



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Emerging Remote Sensing Technologies: Microsats

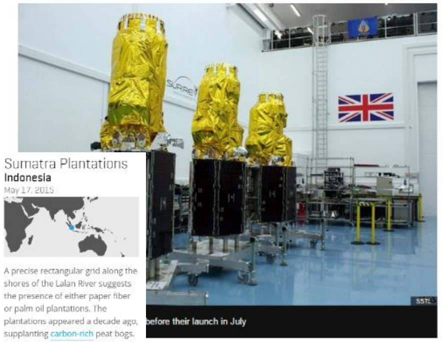
Current and Future Satellite Imagery

	Satellite	Spatial Resolution	Spectral Resolution	Temporal Resolution	Cost	Launch Date
Government:	Landsat 8	30 meter	Visible, NIR, Thermal	Every 17 days	Free	2013
	Sentinel 2a	10 meter	Visible, NIR	Approximately 5 days	Free	2015
	NigeriaSats	22 meter to 4 meter	Visible, NIR			2006 to present
Commercial:	GeoEye-1	2m multi/0.5 pan	Visible, NIR	2 to 8 days	$$$$$*	2008
	Pleiades-1A	2m multi/0.5 pan	Visible, NIR	Daily	$$$$$	2011
	Pleiades-1B	2m multi/0.5 pan	Visible, NIR	Daily	$$$$$	2012
	WorldView-1	0.5 meter pan	Panchromatic	2 days	$$$$$	2007
	WorldView-2	2m multi/0.5 pan	Visible, NIR	1 to 4 days	$$$$$	2009
	WorldView-3	1.24 multi/0.31 pan	Visible, NIR, SWIR	1 to 5 days	$$$$$	2014
	SPOT6 and SPOT7	6 meter multi/ 1.5 meter pan	Visible, NIR	1 day	$$$	2012 and 2014
	Blackbridge	6 meter multi/ 1.5 meter pan	Visible, NIR	1 day	$$	2008
	EROS-B	0.7 meter pan	Panchromatic	6 days	$$$$	2006
	Deimos-2	4 meter multi/1 meter pan	Visible, NIR, Panchromatic	3 days	$$	2014
	SkySat-1 and 2	2 meter multi/0.9 meter pan	Visible, NIR, video panchromatic	5 days	N/A	2013 and 2014
	Kompsat-3	2.8 multi/ 0.7 pan	Visible, NIR, Panchromatic		$$$	2012
	SSTL	4 meter multi/1 meter pan	Visible, NIR, Panchromatic		N/A	2015
Still to come:	Eros-C	0.3			N/A	2017
	Satellogic	1 meter multi/0.5 pan	Visible, NIR, Panchromatic	Every 15 minutes	N/A	2015
	Planet Lab Doves	3 to 5 meter	Visible	Daily	N/A	2015
	UrtheCast	Video	Visible	Daily	N/A	2019
	SkySat	2 meter multi/0.9 meter pan	Visible, NIR, video panchromatic		N/A	2015
	NorStar	N/A	Thermal, hyperspectral	multiple daily	N/A	N/A
	WorldView-4	1.36 meter multi/34cm pan	Visible, NIR, Panchromatic		N/A	2016
	*To make sense for commercial, production agriculture (corn, wheat, soy) needs to come down to $					

Microsatellite Imagery

- Past limitations of availability and cost will likely become a non-factor.
- The Applications for the technology exist.
- Will technology factors limit use:
  - Tying point on ground to point on satellite image
  - Accuracy of information products

Surrey, UK based company "mass" producing satellites



Planet Labs Example image of palm plantation

- Satellite companies, investing millions, need to offer information products to meet revenue goals.
- Will not want to sell imagery as a commodity.
- Competition will reduce price, number of companies but enough?

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Satellogic

Current Satellogic satellites:
Weekly 100 meter hyperspectral imagery

June 2017 satellite launch:
Weekly 1 meter multispectral, 30 meter hyperspectral

Contact

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