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Integration of SWAT into a real-time web-based DS tool for sugarcane irrigation management

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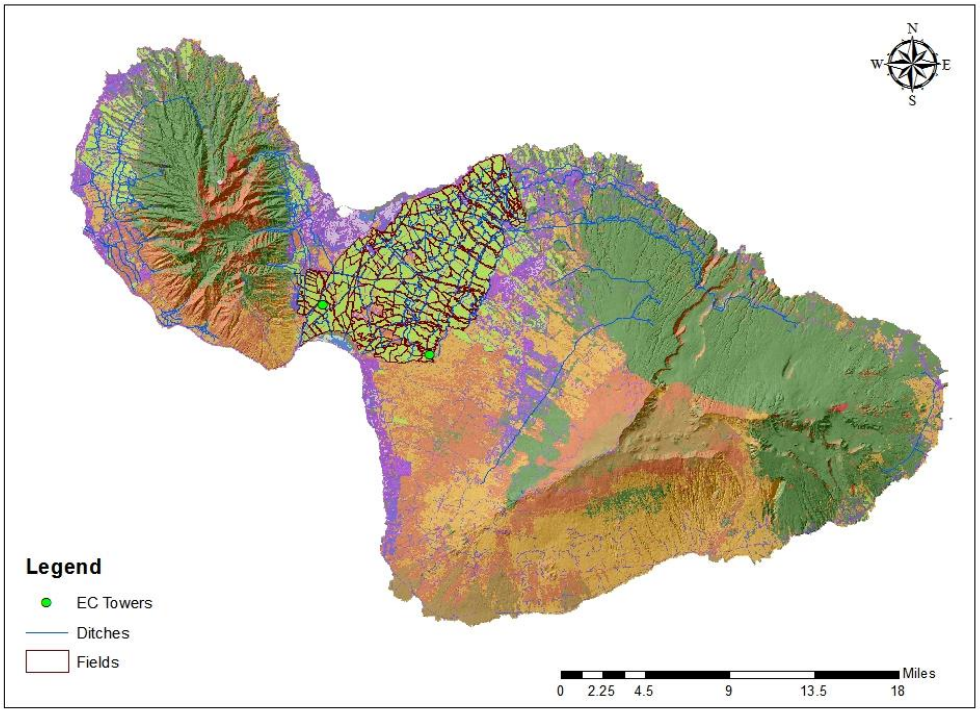
Objectives

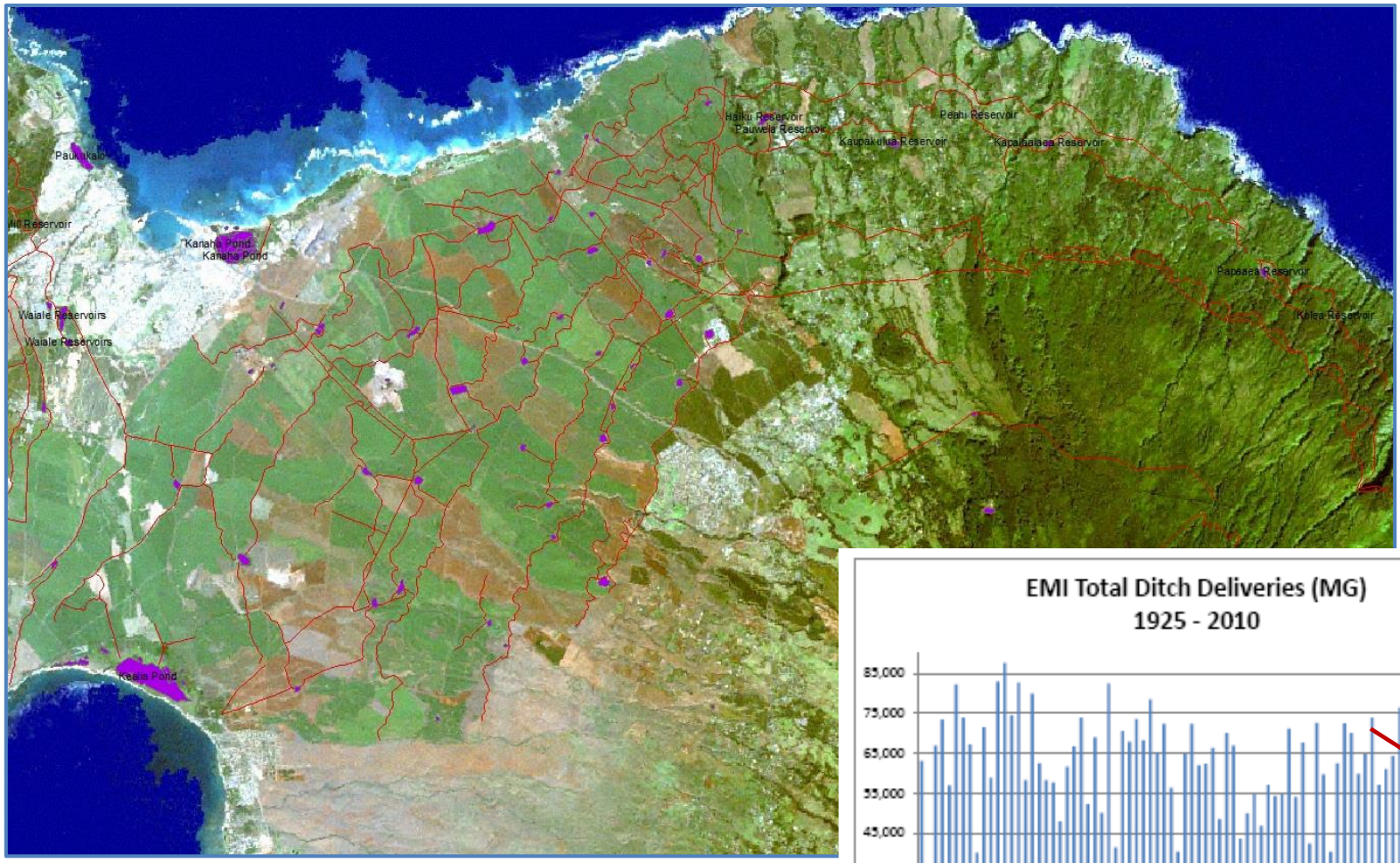
- Develop and calibrate a SWAT model for simulating water balance within the HC&S sugarcane plantation
- Modify SWAT code to allow custom input/output, drip irrigation
- Build a web-based UI that operates SWAT water balance program on a daily basis

Maui sugarcane plantation

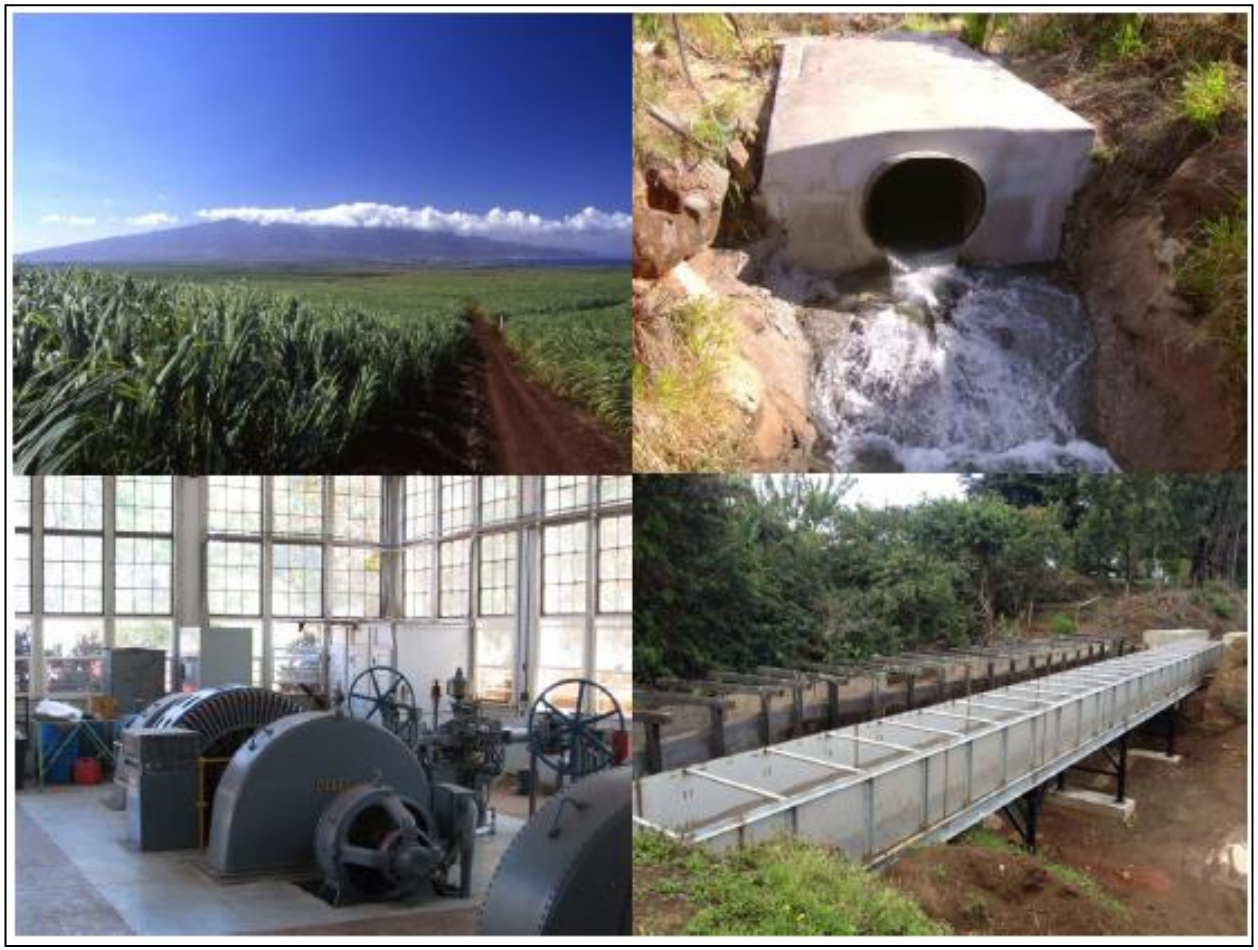


- 141 km^2 under cultivation
- Since 1869
- $130M US dollars revenue
- 2-year harvest cycle
  - 100 tons/ha (dry weight)
- Water for irrigation:
  - Surface sources (rainfall dependent)
  - 16 deep brackish-water wells
- Irrigation:
  - 600 million litters a day
  - Drip irrigation

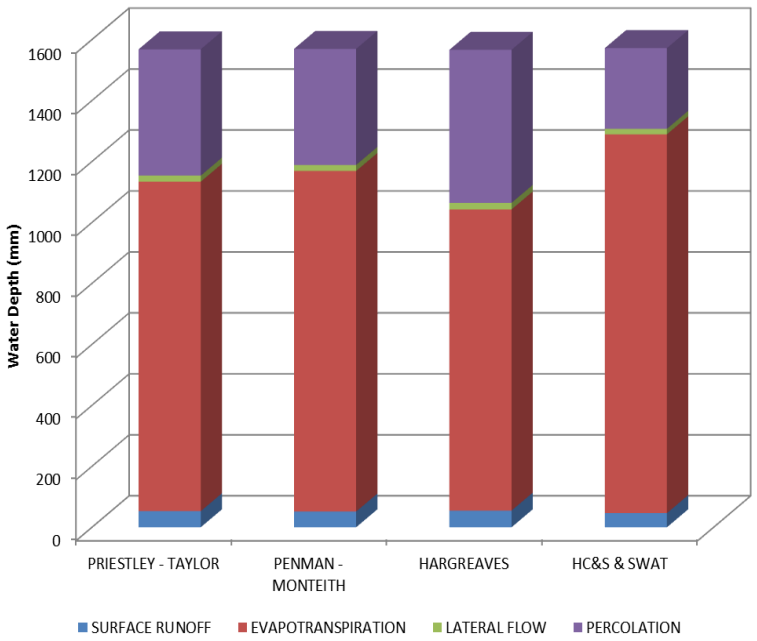
Maui Sugarcane Plantation



Key limiting resource is water



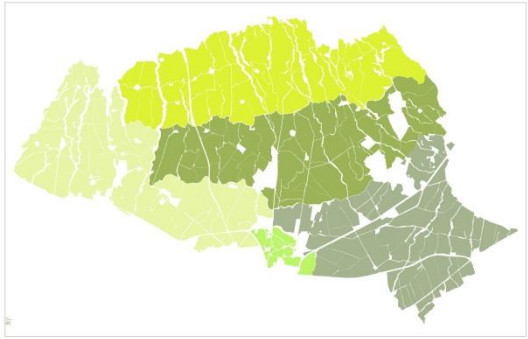
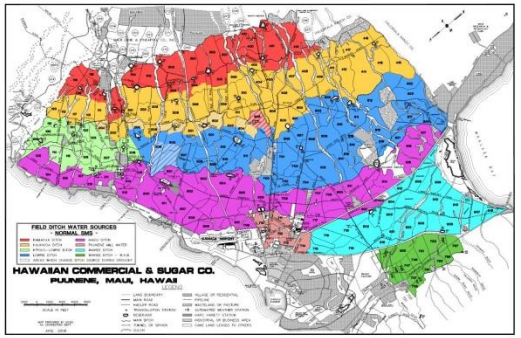
Motivation



(Water balance components as fractions of annual rainfall)

- Current water balance program lacks:
  - Soil moisture calculation
  - Crop growth modeling
  - Soil water – plant interaction
  - Calculation of actual evapotranspiration
- A better tool is needed to support irrigation management

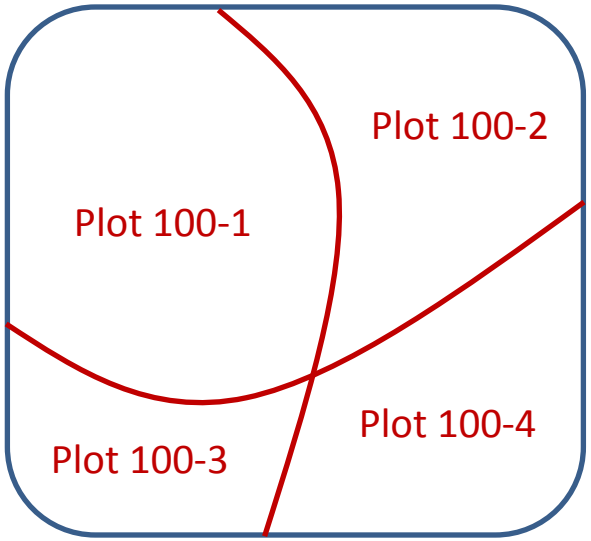
Operation units of the HC&S plantation

Entire Plantation 	Farms (5) 	Supervisors(14) 
Fields (173)=>**Subbasins** 	Blocks (298) 	Plots (701)=>**HRUs** 

SWAT model development

Maui Plantation

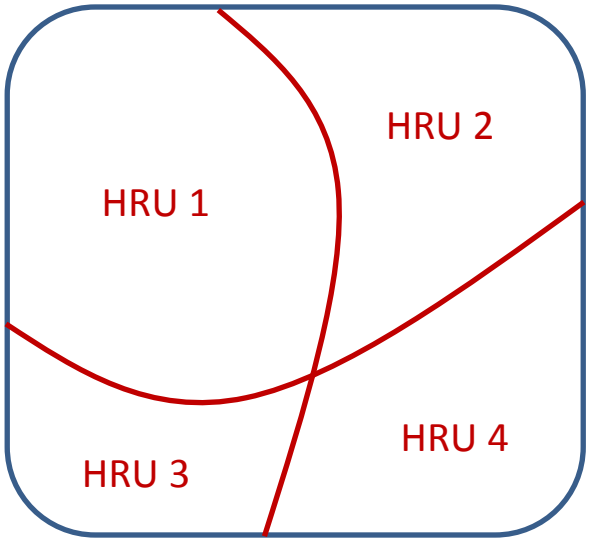
Field 100



71 Soil types

SWAT Model

Subbasin 1



47 Soil types

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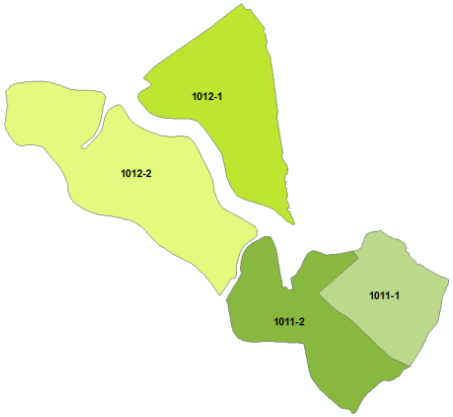
Watersheds definition

AUTOCAD
Polygons
(*.dwg)

Clean up polylines
Export as Shape files

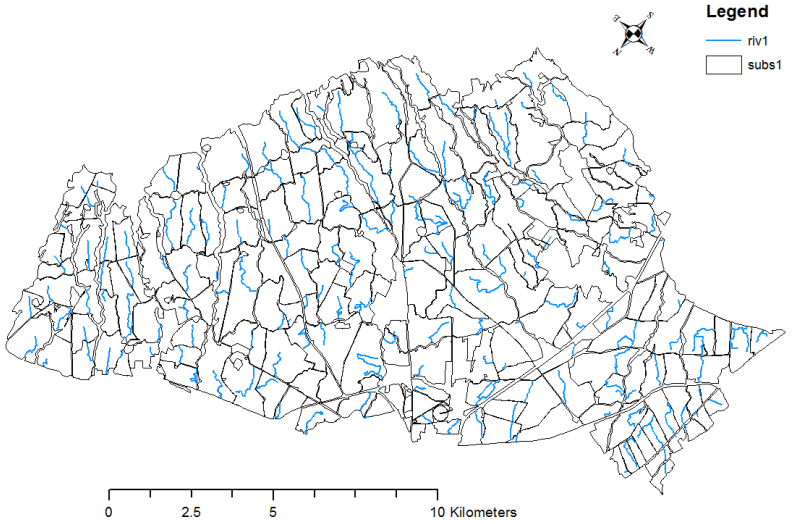
Define projection/datum
Fix negative areas-ArcToolBox /
Repair Geometry Tool



Watersheds and streams definition

- Subbasins Attribute table

	FID	Shape	GRIDCODE	Subbasin
▶	0	Polygon	1	1
	1	Polygon	2	2
	2	Polygon	3	3
	3	Polygon	4	4
	4	Polygon	5	5



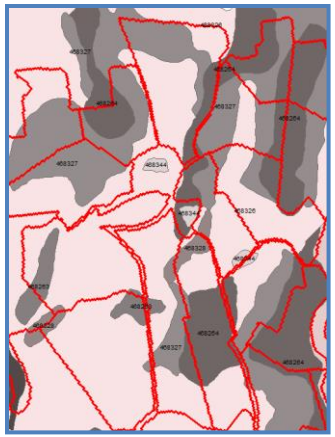
- Streams Attribute table

	FID	Shape	ARCID	GRID_CODE	FROM_NODE	TO_NODE	Subbasin	SubbasinR
▶	0	Polyline	5	1	1	4	1	4
	1	Polyline	6	2	2	4	2	4
	2	Polyline	12	3	3	5	3	5
	3	Polyline	13	4	4	5	4	5
	4	Polyline	14	5	5	0	5	0

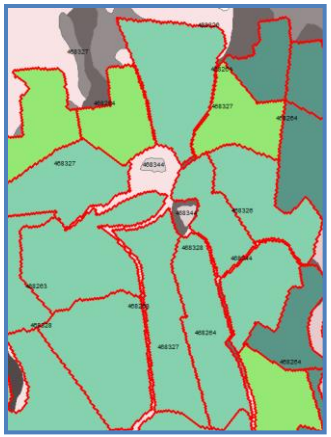
HRUs definition

- A landuse map was created with different dummy sugarcane crops between neighboring plots
- Soil map was recreated such that one plot has a predominant soil type.

SSURGO



ArcToolBox
Preprocessing

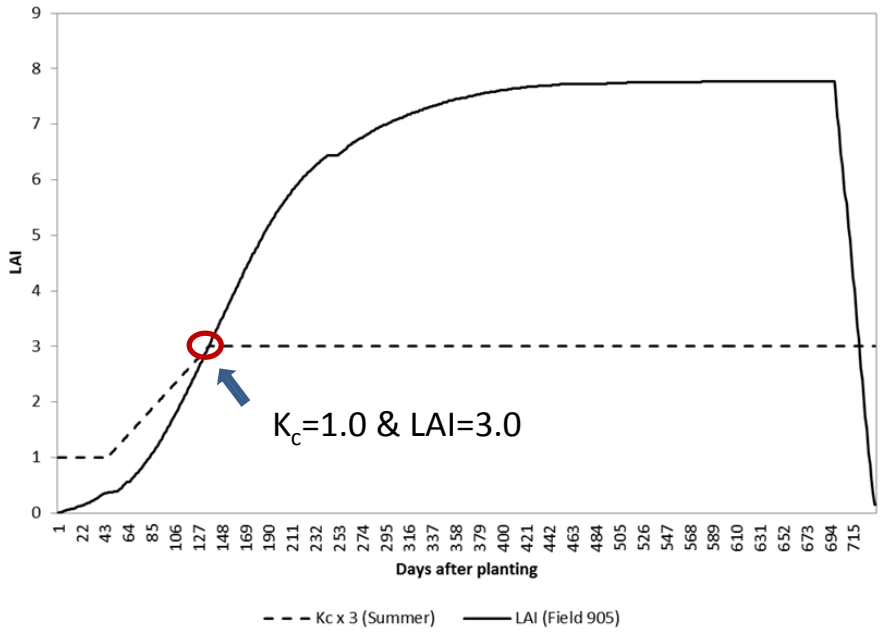


Treated soil map

SWAT code development

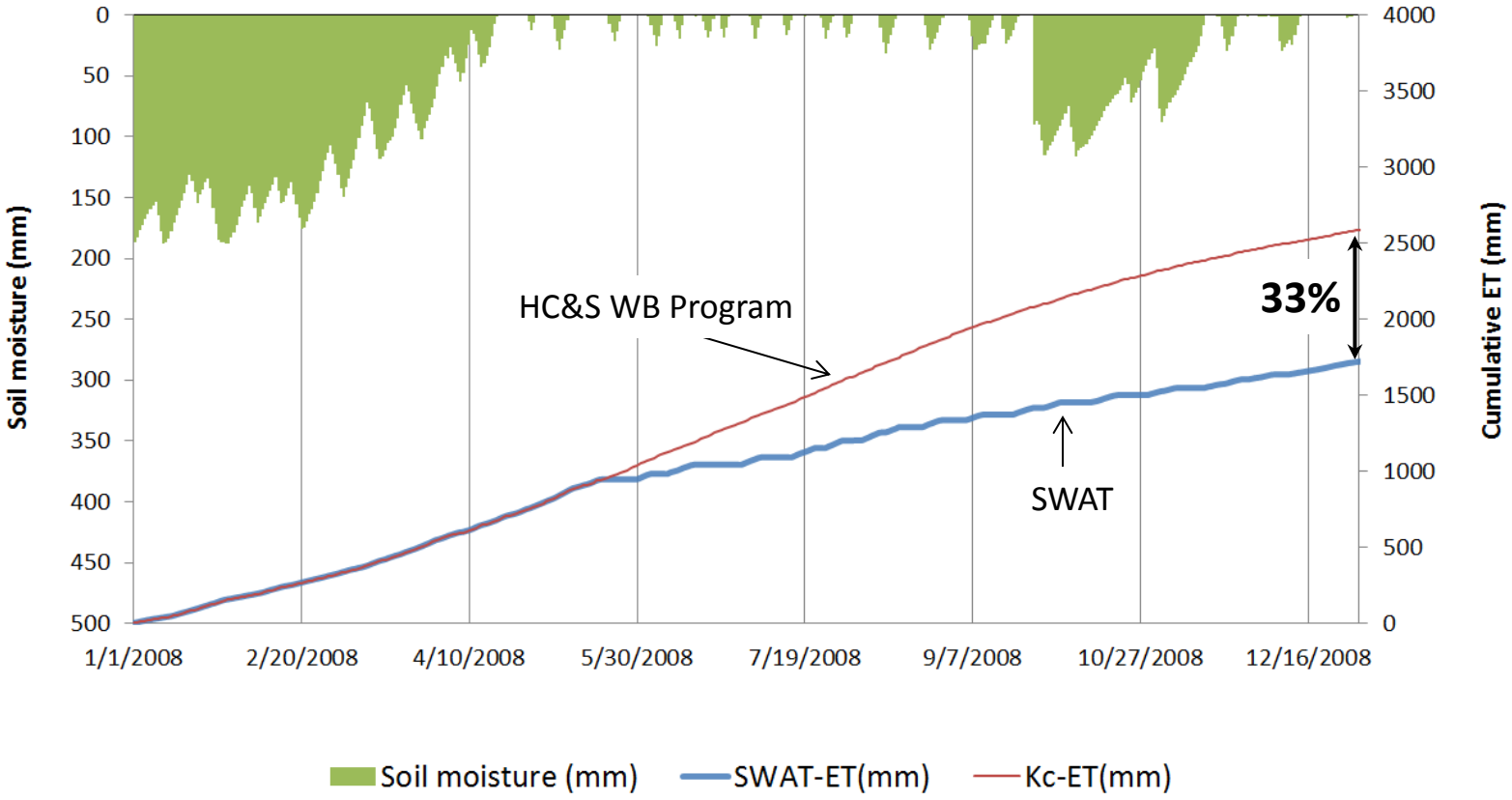
- New algorithms for PET and actual ET estimation
- Crop growth
- Drip irrigation to apply to HRUs
- Interface for custom I/O
  - Precipitation and other daily weather input
  - Daily Irrigation
  - Special output for post-processing

Model parameterization (ET)

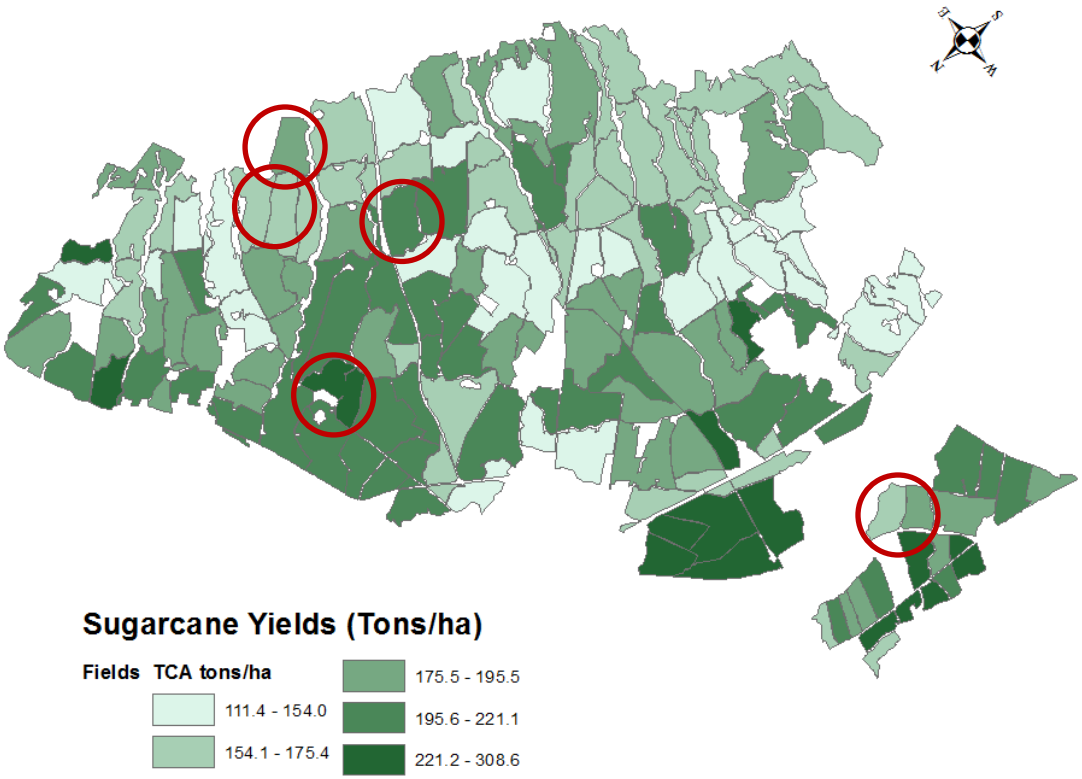


- Crop growth was parameterized for Hawaii sugarcane based on an already established crop coefficient curves.
- Hawaii ET model :
  - $ET_a = K_c \times ET_{ref}$
  - $ET_a = ET_{ref}$ if $K_c = 1.0$
- SWAT
  - $ET_a = ET_{ref}$ if LAI = 3.0 and enough soil/plant moisture available

Estimated actual ET

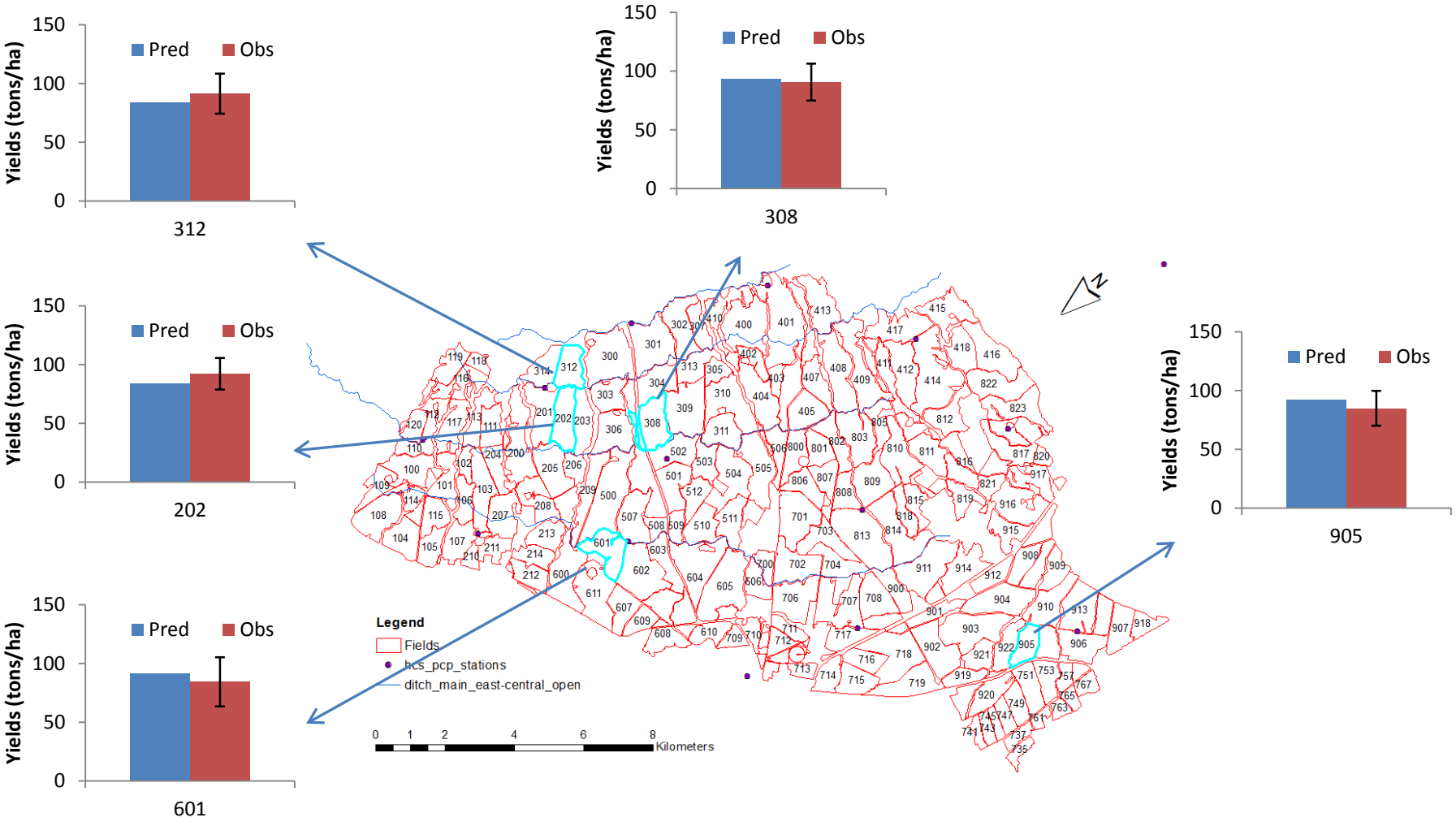


Model Calibration (Crop Yields)



- Fields 202, 308, 312, 601, 905
- Average sugarcane yields for 2000-2011
- Calibration parameters:
  - Crop parameters
  - Biomass reduction by a burning operation (~15%)
  - Moisture contents in fresh yields (~65%)
  - GW and soil parameters

Estimated Average Crop Yields



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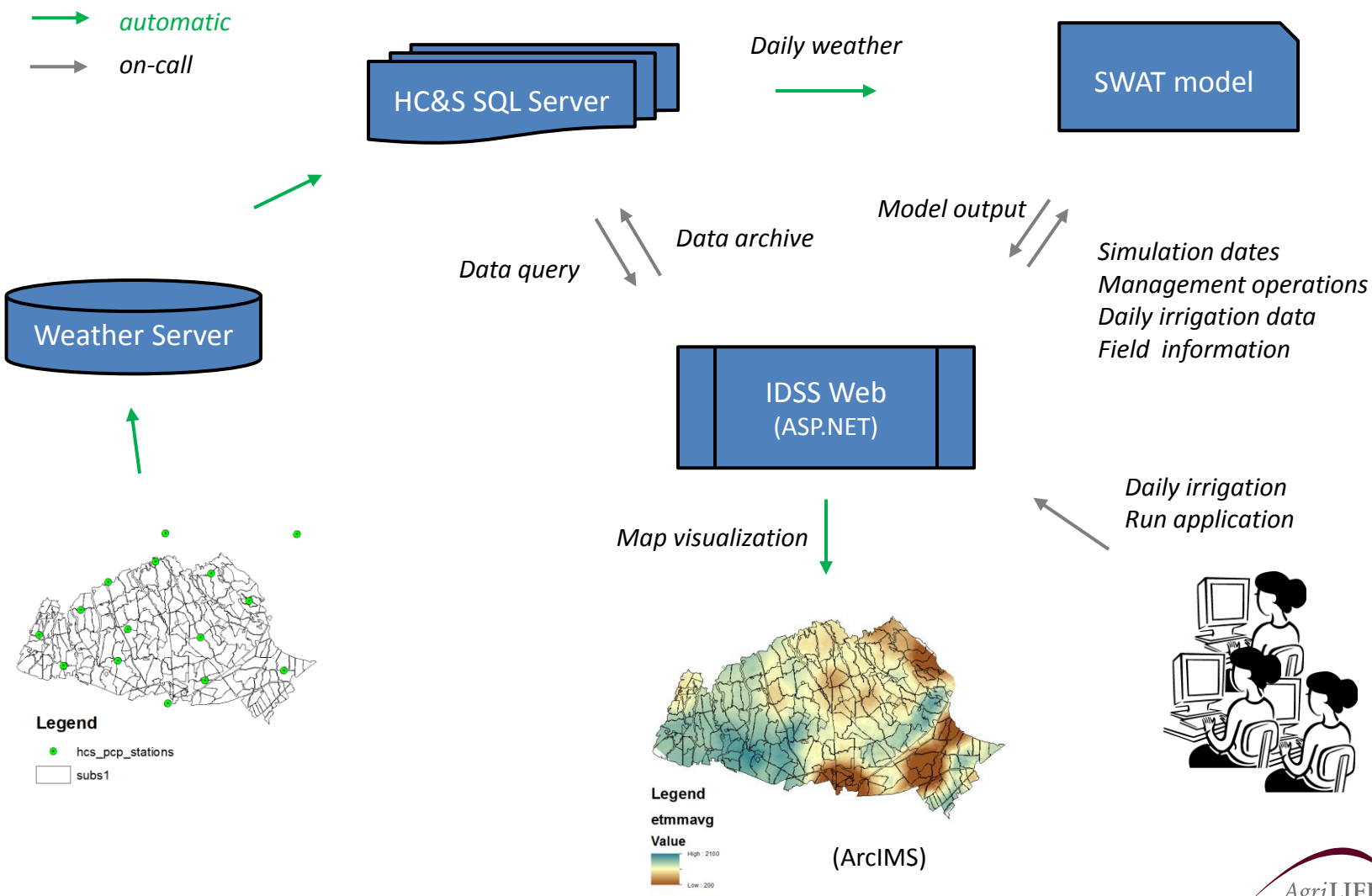
Irrigation Decision Support System



Summary

- Rainforest water is the most influential factor that affects sugarcane productivity on Maui
- Irrigation Decision Support System (IDSS) is a web-based visual application of SWAT for predicting daily water balance of the HC&S sugarcane plantation
- Using custom watershed/river definitions, ArcSWAT 2009 created a SWAT model that precisely resembles the real plantation
- SWAT predicted lower ET than the crop coefficient method by 33 percent/yr for a upland field with the consideration of soil moisture
- Predicted sugarcane yield compares well with measured values
- Building SWAT into a fully real-time simulation tool is a major challenge
- ASP.NET is a useful framework to incorporate SWAT into a web-based simulation tool, feeding on relational databases

Question?

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