Presenting GIS Solutions for Permaculture Design:

A specific suitability analysis and discussion of other useful spatial functionality

By Tommy McKoy

Research Questions

GENERAL

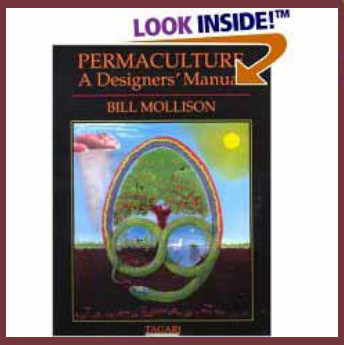
- How can GIS be useful in permaculture design?
  - Why not just use Illustrator and/or Excel?

SPECIFIC

- Where do you place a composting toilet facility?

Permaculture Defined

- Permaculture is the conscious design and maintenance of agriculturally productive ecosystems which have the diversity, stability, and resilience of natural ecosystems. It is the harmonious integration of landscape and people providing their food, energy, shelter and other needs in a sustainable way.



- The Permaculture Research Institute

Permaculture Mission Statement

- Our goal is to integrate waste and energy education in a self-sustaining and efficient system. This means using existing & potential social, economic, & ecological capital in a financially & technically feasible manner.

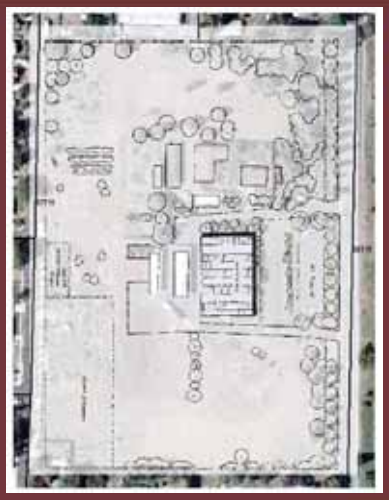
- From the Waste and Energy team, Permaculture II Design Course, Learning Gardens Lab

Goals

- Minimize waste
- Minimize energy usage
- Minimize actual load
- Close the loop
  - Creating a self-sustaining system
- Maximize on-site resources
- Integrate waste & energy education on-site

Datasets Used

- Satellite Imagery Photo, streets layer (RLIS)
- Base map produced by "Overall Site" permaculture team
  - Georeferenced this to the Sat photo
- Polygon shapefiles Produced using Editor in ArcMap
  - Polygons drawn from measurements taken on site
  - Important elements identified during Site Assessment
  - Could / should have GPS units been used?



Site Assessment – Permaculture Methods

Organic Materials
- Mulch
- Compost
- Garden roughage

Human Resources
- PSU Students
- Site Educators
- Site managers and maintenance crew
- Existing Gardens and Natural Resources

Connections
- Portland Parks and Recreation
- Oregon Energy Trust
- Portland Public Schools
- PSU

Useful Buildings
- Green Houses
- Classroom Complex

Needs/Yields Assessment

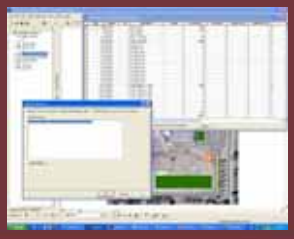
NEEDS
- Money
- Technical Knowledge
- Brown Compostable Material
- Sustainable heating source
- Wood chipper
- Educational Signage
- Energy/Waste Audits

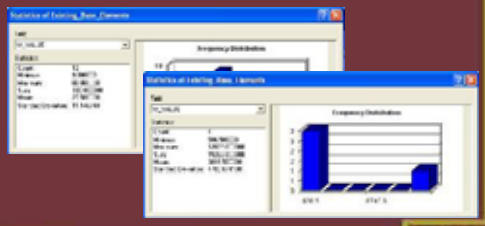
YIELDS
- Compost
- Garbage
- Human waste
- Human energy

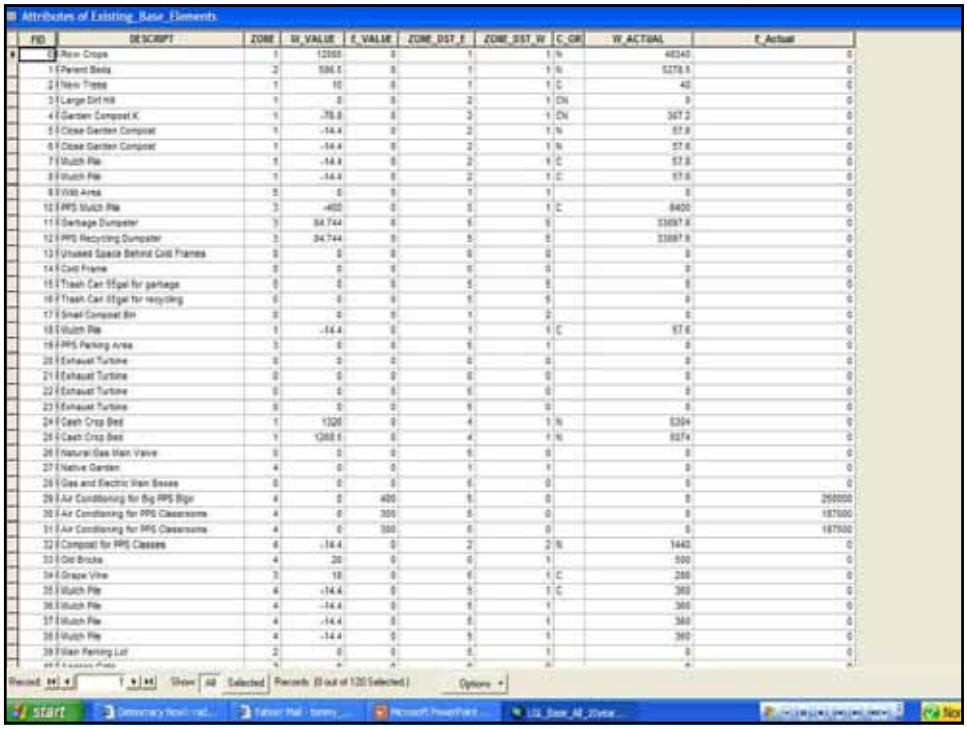
Methods for General Problem Statement

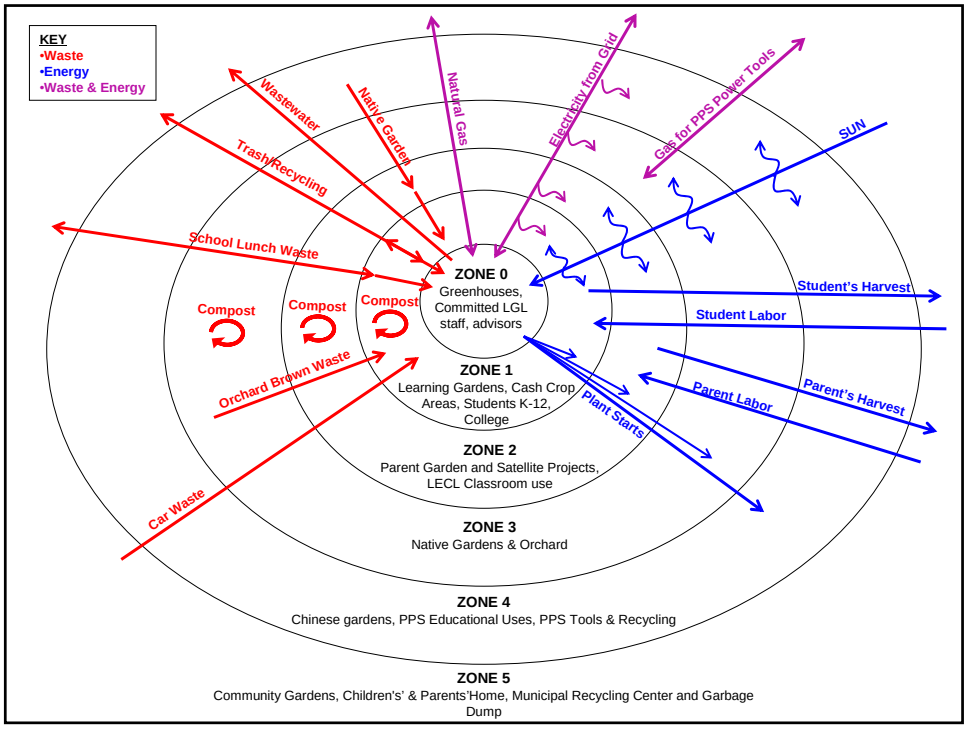
(How can GIS be useful in permaculture design?)

- Maintain Attribute Table
  - Add fields for description, zone, energy weight, waste weight, zone distance (W & E), Carbon / Nitrogen, and “actual weights”
  - Use combination of query builder, spatial joins, SQL, and calculate areas tool









Base Map: Zone System

Zonal elements not shown on map:

Zone 0: Core LGL Staff and LECL Advisors

Zone 1: Students from K-12 and PSU

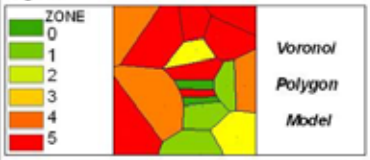
Zone 2: Parents and extra LGL/PSU classroom use

Zone 3: PPS Facilities

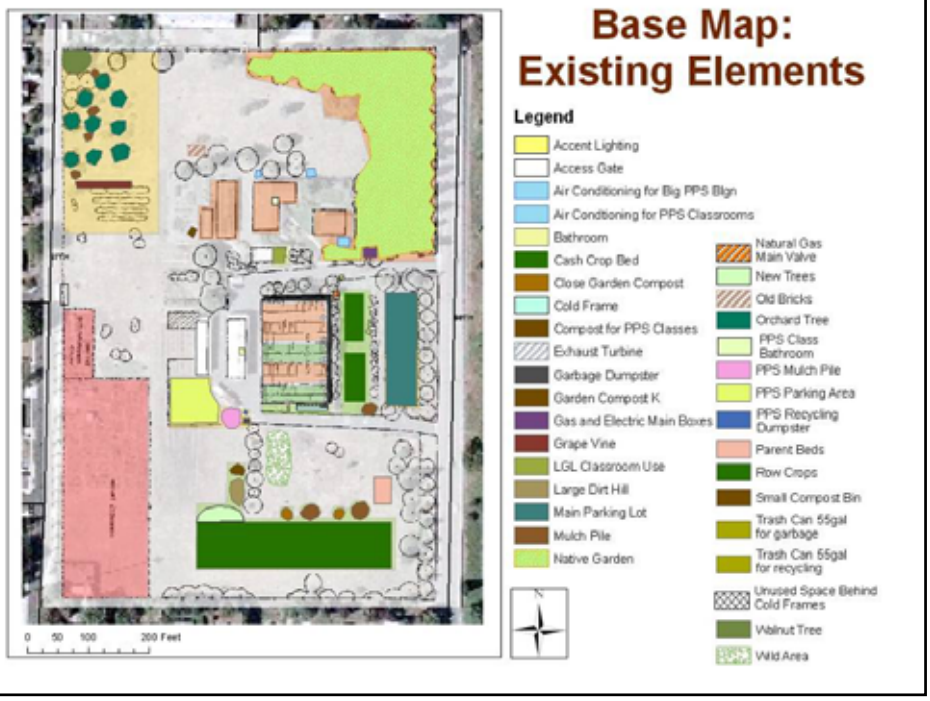
Zone 4: PPS education uses, farm markets

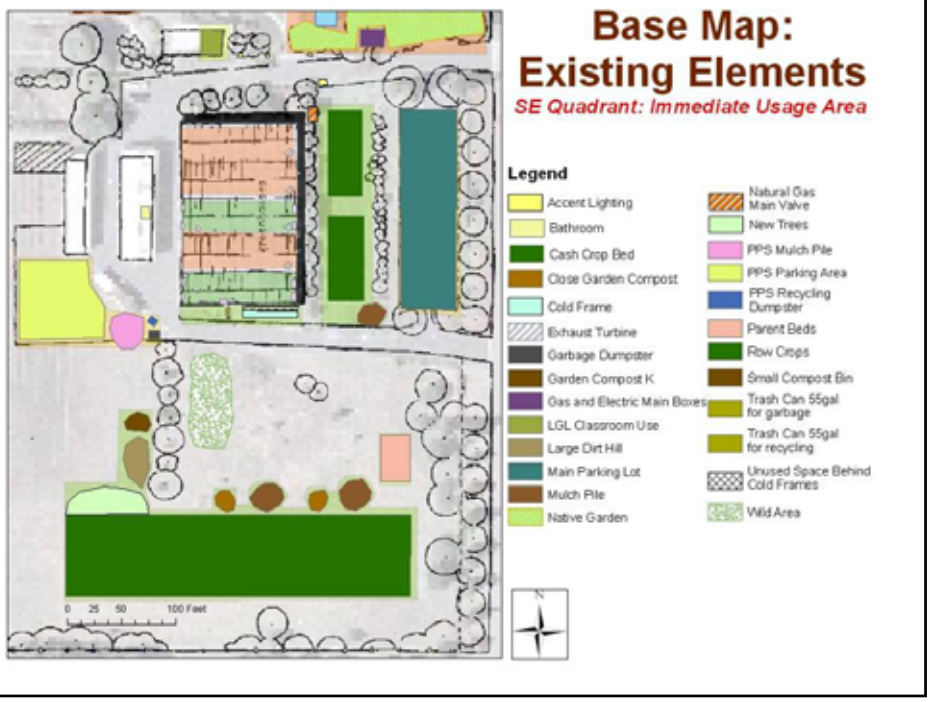
Zone 5: Garbage and recycling facilities, parents' and students' houses

Legend

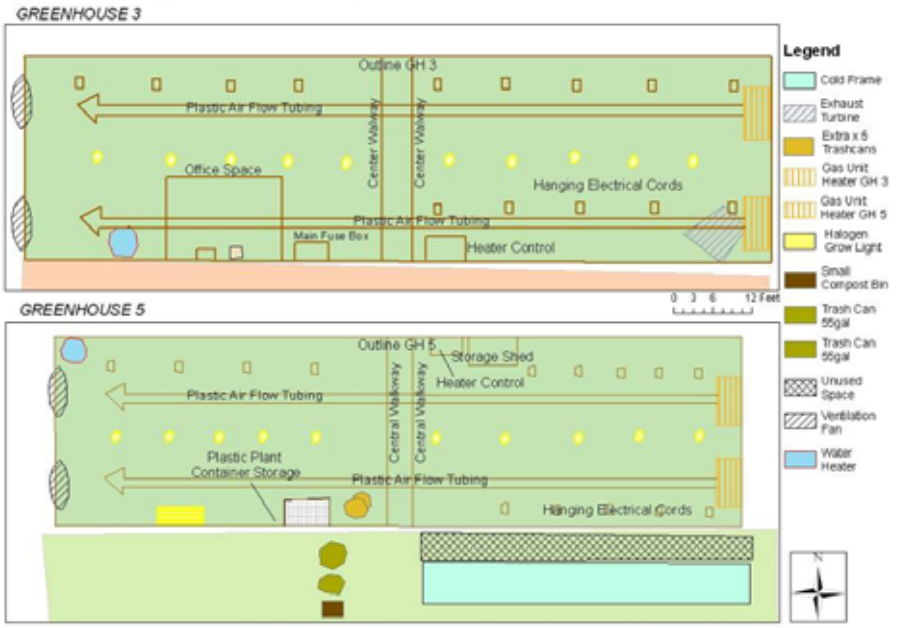


This graphic displays Voronoi polygons, a statistical analysis mapping method of extrapolating a value for every point on the map from the existing polygons.


Base Map:
Existing Elements
Legend
Accent Lighting
Access Gate
Air Conditioning for Big PPS Bldg
Air Conditioning for PPS Classrooms
Bathroom
Cash Crop Bed
Close Garden Compost
Cold Frame
Compost for PPS Classes
Exhaust Turbine
Garbage Dumpster
Garden Compost K
Gas and Electric Main Boxes
Grape Vine
LGL Classroom Use
Large Dirt Hill
Main Parking Lot
Mulch Pile
Native Garden
Natural Gas Main Valve
New Trees
Old Bricks
Orchard Tree
PPS Class Bathroom
PPS Mulch Pile
PPS Parking Area
PPS Recycling Dumpster
Parent Beds
Row Crops
Small Compost Bin
Trash Can 55gal for garbage
Trash Can 55gal for recycling
Unused Space Behind Cold Frames
Walnut Tree
Wild Area
0 50 100 200 Feet


Base Map:
Existing Elements
SE Quadrant: Immediate Usage Area
Legend
Accent Lighting
Bathroom
Cash Crop Bed
Close Garden Compost
Cold Frame
Exhaust Turbine
Garbage Dumpster
Garden Compost K
Gas and Electric Main Boxes
LGL Classroom Use
Large Dirt Hill
Main Parking Lot
Mulch Pile
Native Garden
Natural Gas Main Valve
New Trees
PPS Mulch Pile
PPS Parking Area
PPS Recycling Dumpster
Parent Beds
Row Crops
Small Compost Bin
Trash Can 55gal for garbage
Trash Can 55gal for recycling
Unused Space Behind Cold Frames
Wild Area
0 25 50 100 Feet

Base Map: Existing Elements in Greenhouses



Base Map: Existing Elements

Legend

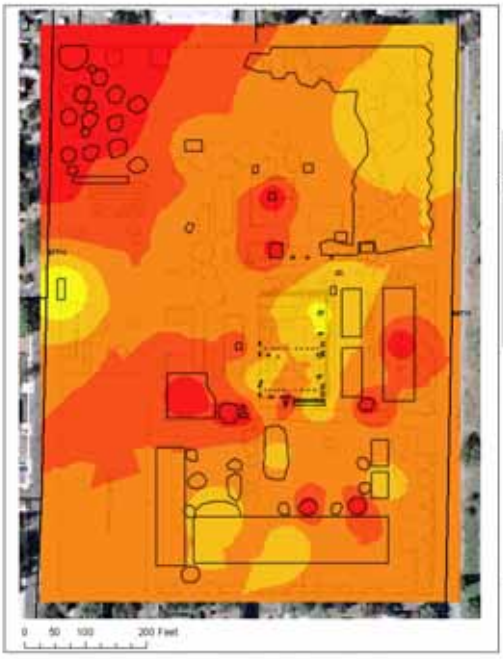
Existing_Base_Elements

W_ACTUAL

- 0.000000
- 0.000001 - 36.000000
- 36.000001 - 57.599998
- 57.599999 - 360.000000
- 360.000001 - 5304.000000
- 5304.000001 - 10800.000000
- 10800.000001 - 13500.000000
- 13500.000001 - 48340.000000
- 48340.000001 - 84744.000000
- 84744.000001 - 160000.000000

Formual Used for W_Actual - the realistic load that each element has on the system:

(([ZONE] +1) * ([ZONE] +1)) * Abs ([W_VALUE]) * [ZONE_DST_W] * [ZONE_DST_W]



Base Map:
Site Assessment of Zone Distance and Actual Load

Legend
Inverse Distance Weighting
Prediction Map of Zone Distance
0 - 1
1 - 2
2 - 3
3 - 4
4 - 5

Total E_Actual = 2,159,500

Total W_Actual = 723,775

Formual Used for W_Actual -
the realistic load that each element has on the system:
(([ZONE] +1) * ([ZONE] +1)) *
Abs ([W_VALUE]) * [ZONE_DST_W] * [ZONE_DST_W]

Formual Used for E_Actual -
the realistic load that each element has on the system:
([ZONE] + 1) * ([ZONE] + 1) *
Abs ([E_VALUE]) * [ZONE_DST_E] * [ZONE_DST_E]

Composting

- Leaf Compost
  - Leaf mold
- Vermicompost
  - Worm bins & beds
  - Windrow/Wedge System
  - Reactor Systems
- Composting Toilet
- Combining Methods




Renewable Energy Project

Possible Energy Projects

- Biomass: agricultural bi-products burned for power generation, financial assistance available
- Solar: Trim15 % or more off your electric bill and get credited for excess power
- Wind: Financial assistance for small turbines ranging from1000 watts to approx. 600 kilowatts

(Visit http://www.energytrust.org)

EnergyTrust of Oregon, Inc.

Plans for the Future

- 1 Year Plan
  - Add Compost Bins/Piles
  - Energy & Waste Audits
  - Energy Efficient Light Bulbs
  - Educational Signage
  - Integrate permaculture/renewable energy into education
  - Coordinate with PPS

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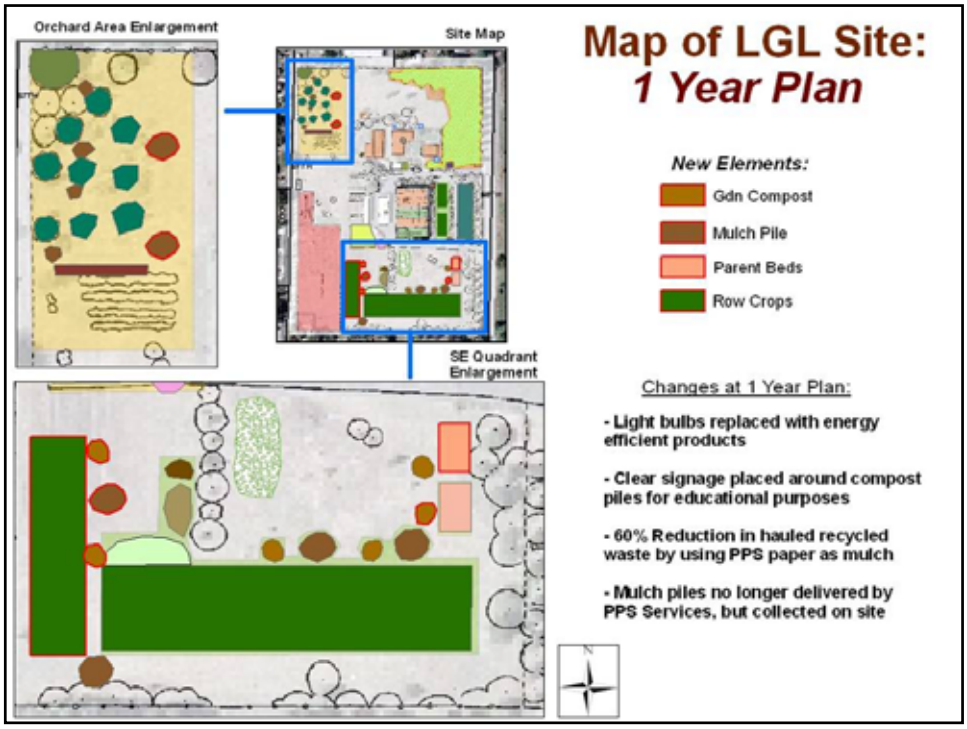
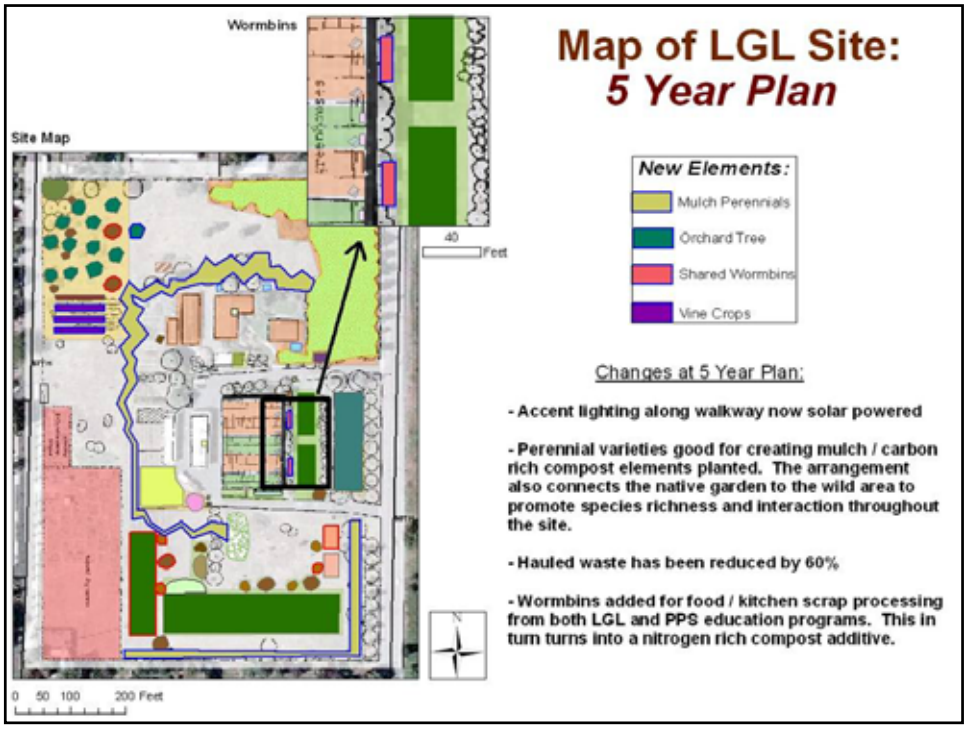


Plans for the Future

- 5 Year Plan
  - Reduce hauled waste by 60%
  - Solar path lights
  - Increase perennials
  - Diversify compost
  - Produce renewable energy & fundraising plans
  - Buy educational tools/resources



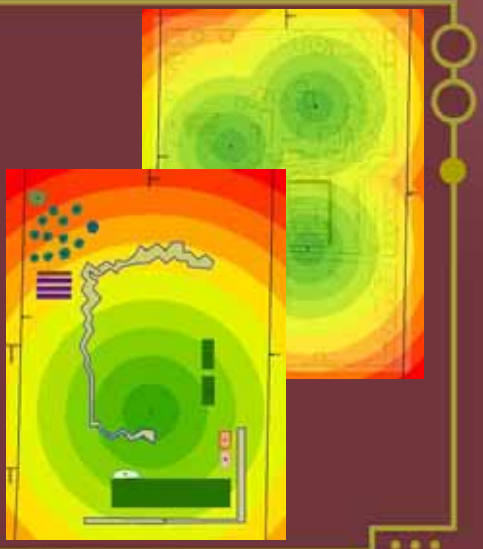
Plans for the Future

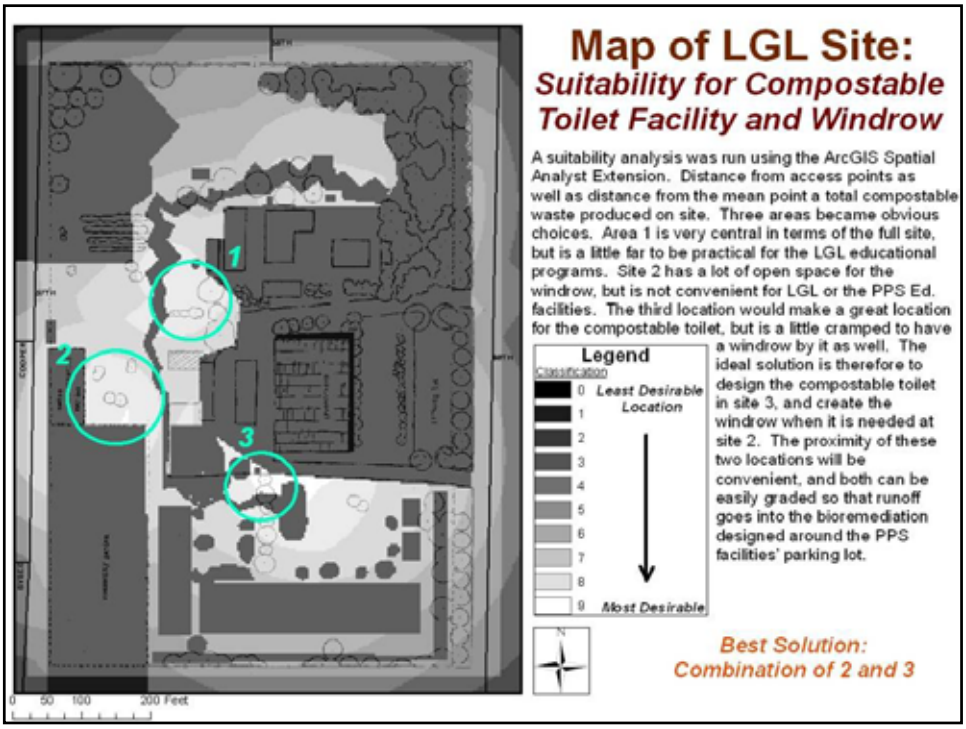
- 10+ Year Plan
  - Reduce dependence on BPA by 60%
  - Implement renewable energy plans
  - Composting toilet
  - Integrate animals
  - Closed-loop system
  - Bioremediation
  - Windrow/wedge system?

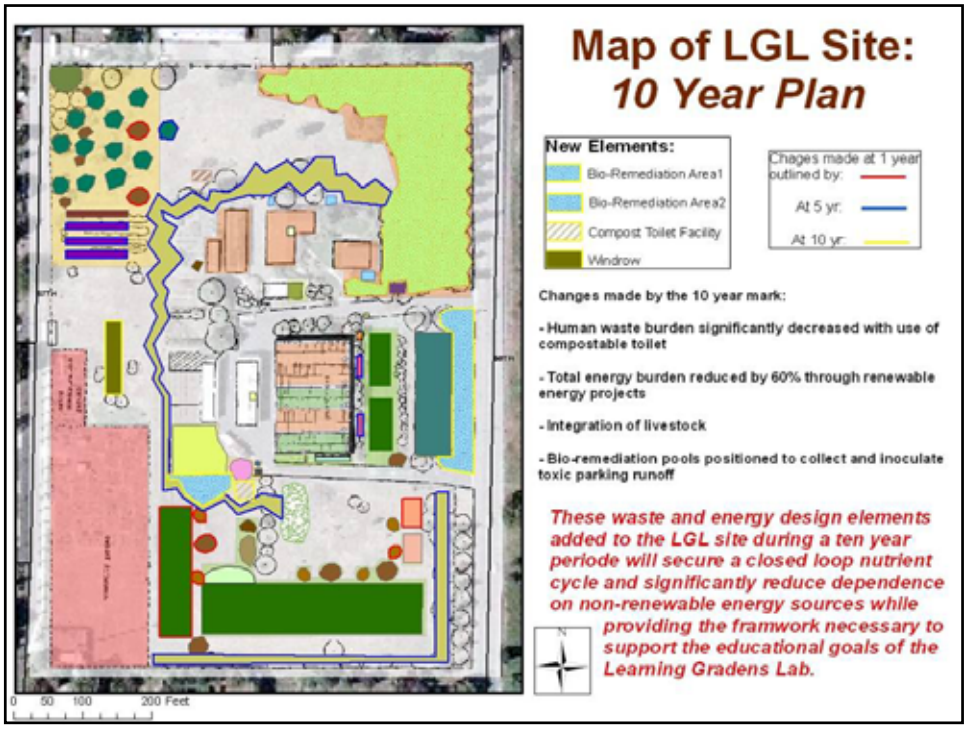


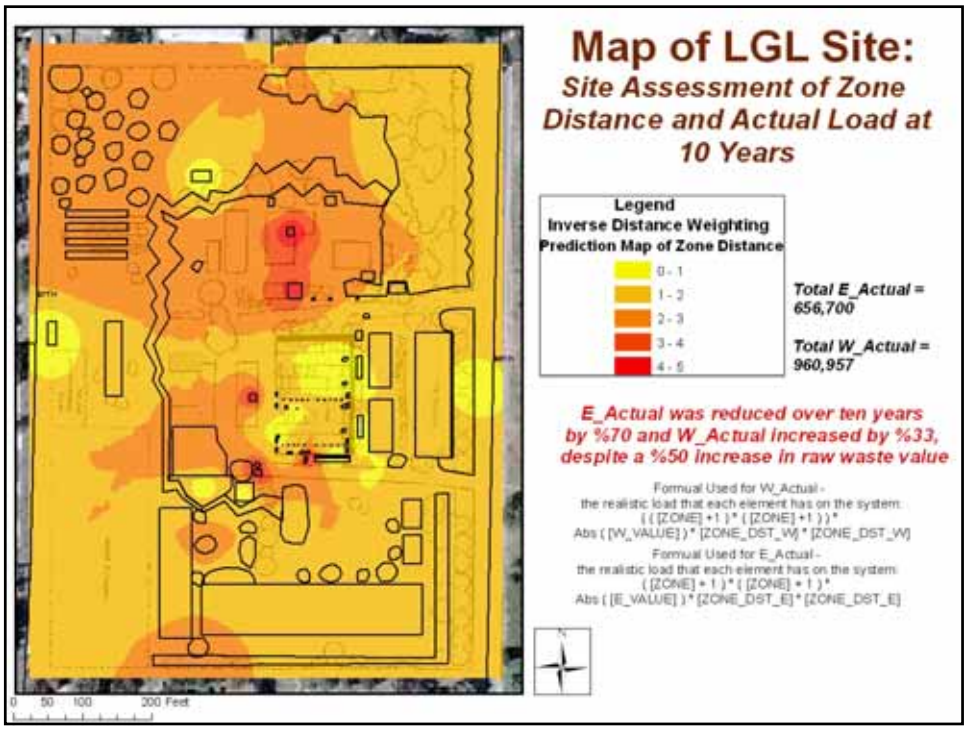

GIS Methods: Suitability Analysis

- Set up parameters of Spatial Analysis
- Design Shapefile with points at access points around site
- Find geometric mean center of compost contributions by volume (Mean Center Tool)
- Buffer again…
- Convert to rasters
- Reclassify
- Raster Calculator






Map of LGL Site:
10 Year Plan
New Elements:
Bio-Remediation Area1
Bio-Remediation Area2
Compost Toilet Facility
Windrow
Chages made at 1 year outlined by:
At 5 yr:
At 10 yr:
Changes made by the 10 year mark:
- Human waste burden significantly decreased with use of compostable toilet
- Total energy burden reduced by 60% through renewable energy projects
- Integration of livestock
- Bio-remediation pools positioned to collect and inoculate toxic parking runoff
These waste and energy design elements added to the LGL site during a ten year periode will secure a closed loop nutrient cycle and significantly reduce dependence on non-renewable energy sources while providing the framwork necessary to support the educational goals of the Learning Gradens Lab.
0 50 100 200 Feet

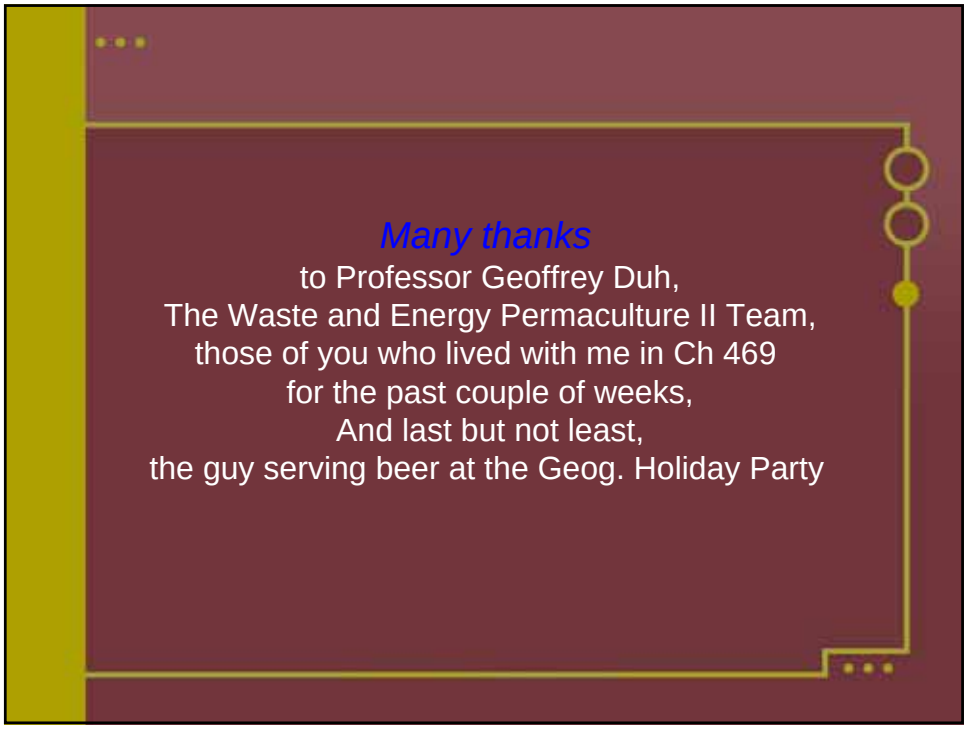

Map of LGL Site:
Site Assessment of Zone Distance and Actual Load at 10 Years
Legend
Inverse Distance Weighting
Prediction Map of Zone Distance
0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
Total E_Actual = 656,700
Total W_Actual = 960,957
E_Actual was reduced over ten years by %70 and W_Actual increased by %33, despite a %50 increase in raw waste value
Formual Used for W_Actual -
the realistic load that each element has on the system:
(([ZONE] +1) * ([ZONE] +1)) *
Abs ([W_VALUE]) * [ZONE_DST_W] * [ZONE_DST_W]
Formual Used for E_Actual -
the realistic load that each element has on the system:
([ZONE] + 1) * ([ZONE] + 1) *
Abs ([E_VALUE]) * [ZONE_DST_E] * [ZONE_DST_E]
0 50 100 200 Feet

What use is GIS for Permaculture?

- Visualization / educational purposes
- Immediate calculation of areas
- Direct Measurement
- Multiple function suitability mapping
- Finding the "least cost path"
- "Spatial join" capabilities so that as you move elements around they take on the zonal attributes of their new location
- GIS only used after in depth site research
- Possible to import wind, solar, and other important vectors right on top of your map

Resources Used

- Link to compost volume estimation: http://www.des.state.nh.us/swtas/pdf/estimating_piles.pdf
- About windrows: http://www.epa.gov/epaoswer/non-hw/composting/windrow.htm http://en.wikipedia.org/wiki/Windrow_composting
- Waste container volume estimation: http://www.business.brookes.ac.uk/research/ceshi/waste_counts_ebook.pdf
- Estimating Weight from Volume: http://compost.css.cornell.edu/factsheet2.pdf
- Composting Toilets: http://www.jenkinspublishing.com/manual.html
- Hemenway, Toby. *Gaia's Garden: A Guide to Home-Scale Permaculture* (Chelsea Green)
- Holmgren, David. Permaculture: *Principles and Pathways Beyond Sustainability.* (Chelsea Green)
- Mollison, Bill. Permaculture: *A Designer's Manual* (Tagari Press)


Many thanks
to Professor Geoffrey Duh,
The Waste and Energy Permaculture II Team,
those of you who lived with me in Ch 469
for the past couple of weeks,
And last but not least,
the guy serving beer at the Geog. Holiday Party