Conservation Applications of LiDAR Data

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Conservation Applications of LiDAR Data

Presented by:

University of Minnesota

In collaboration with:

Minnesota Board of Water and
Soil Resources

USDA Natural Resources
Conservation Service

Minnesota Department of
Natural Resources

tsp.umn.edu/lidar

Conservation Applications of LiDAR Data

Training Modules

Basics of Using LiDAR Data

Terrain Analysis

Hydrologic Applications

Engineering Applications

Wetland Mapping

Forest and Ecological Applications

tsp.umn.edu/lidar

Introductions - Logistics

USB drives

Workbooks

Break after Exercise 2

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Wetland Mapping

What we'll cover in this segment

Introduction

Quick review of Previous Modules

Creating the Hydrologic Layers

Classifying the Wetland Areas

Review of Procedures and Caveats

Introduction

Purpose of this Series
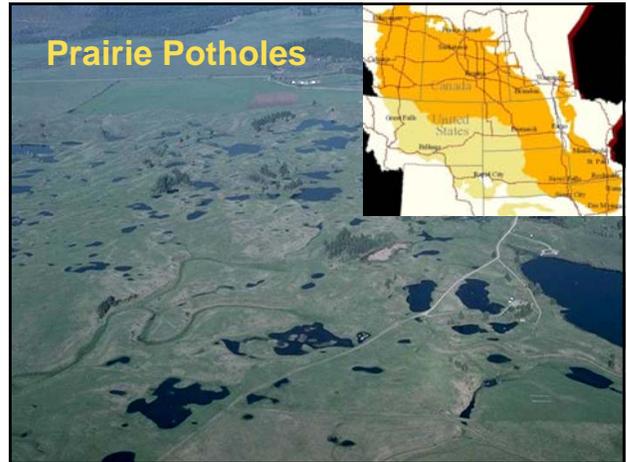
Why we care about wetlands

What is a wetland?

Clean Water Act, section 404: "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."

Photos from:
http://www.npwrc.usgs.gov/resource/plants/innplant/season.htm

Prairie Potholes

Why do we care about wetlands?

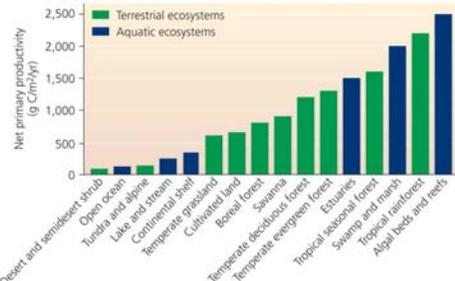Wetlands provide invaluable ecosystem services:

Wildlife habitat, spawning areas

Why do we care about wetlands?

Wetlands provide invaluable ecosystem services:

Biodiversity / Net Primary Productivity

Why do we care about wetlands?

Wetlands provide invaluable ecosystem services:

Water storage on the landscape, groundwater recharge

Red River floods: 1979, 1997, 2009, 2010, 2011, 2012?

Why do we care about wetlands?

Wetlands provide invaluable ecosystem services:

Filtration of sediments, pollutants

Why do we care about wetlands?

Wetlands provide invaluable ecosystem services:

Carbon sequestration

Wetlands may hold 35% of terrestrial carbon
(and may account for 15-20% of atmospheric methane).

Wetlands are vitally important,

Wetlands are vitally important, but…

- In MN, 50% of pre-settlement wetlands have been drained
- In the corn belt, 85-90%
- California: 95%

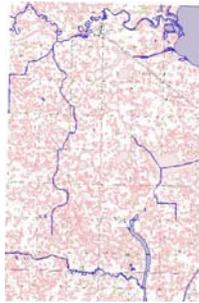## MN Wetland Loss by Region

MN has ~50% wetland loss

< national average of 54%

But > 90% loss in corn belt

60% loss in transition zone

Modest loss in boreal zone

Wetlands are vitally important, but…

- USFWS Restorable Wetland Inventory
- Example from SW MN
- Heron Lake watershed
- Pink = drained wetlands

Wetlands are vitally important, but…

Wetland-related laws

- Section 404, CWA: established permitting system for impacts on "waters of the United States"
- Minnesota Wetland Conservation Act: "no net loss of wetlands"
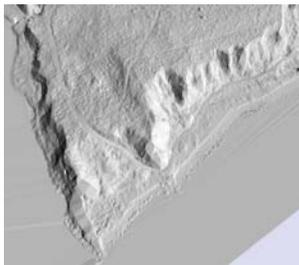
Mapping wetlands

LiDAR

What is LiDAR?

- Light Detection And Ranging – a remote sensing system used to collect topographic data

- Produces high-resolution, accurate, land-elevation information

Review of Previous Segments

How does LiDAR work?

The concept of LiDAR is simple, as it uses the simple relation that:

distance to an object = speed x time.

Essentially, the **time** for the light to travel to and from the target is then used to determine the distance.

The **distance** to the target and the position of the airplane is then used to determine the elevation and location.

Review of Previous Segments

What is LiDAR?

Light detection and Ranging (LiDAR), sometimes referred to as scanning laser altimetry, is a widespread technology that allows the relative height of surfaces to be measured from an aircraft or satellite sensor.
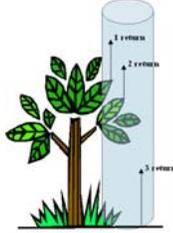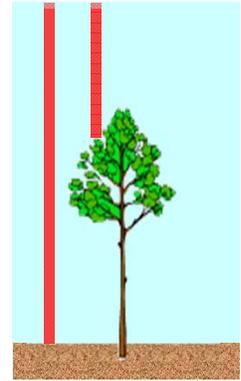

Returns

Single Return
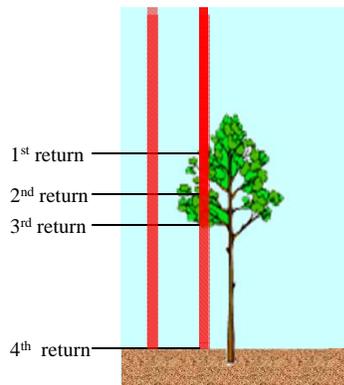
Multiple returns

Waveform Returns

Credit - USGS

Returns

Single Return

Multiple returns

Waveform Returns

1st return
2nd return
3rd return

4th return
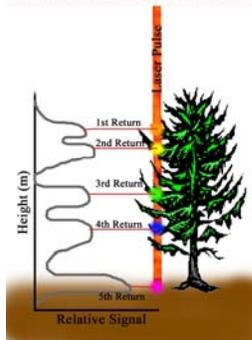

Credit - USGS

Returns

🌀 **Single Return**

🌀 **Multiple returns**

🌀 **Waveform Returns**

Multiple Return Explanation

Credit - USGS

Intensity

Intensity = amount of energy reflected for each return

Different surfaces reflect differently based on wavelength of laser
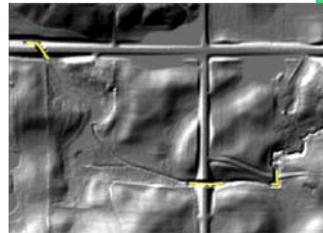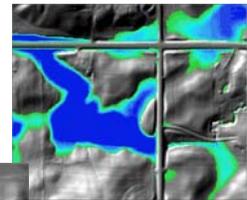
Example at 1064nm (NIR), water absorbs, vegetation highly reflective
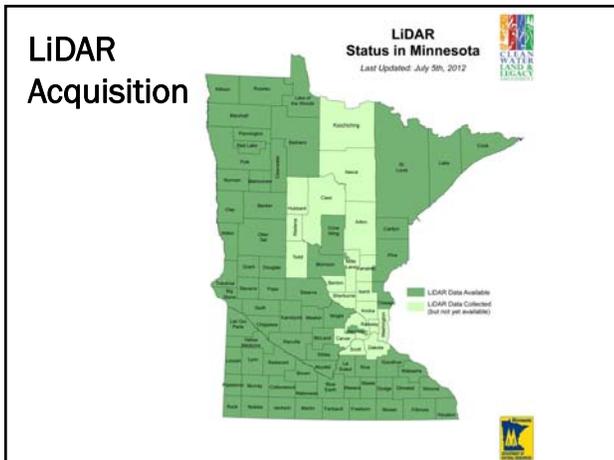
Can be used to build black and white near-IR images

Credit - USGS

Hydrologic Modeling

Identify appropriate water conveyance

Watersheds

LiDAR Acquisition

Wetland Mapping

Wetland Mapping

Exercises are based on research performed at the U of M

Topography, land cover and soil type are primary drivers of wetland determination

Data used

- Hydrographic datasets (DNR 24K streams and lakes, USFWS Wetland Inventory, etc)
- LiDAR derived elevation data- 3M DEM
- 2008 NAIP Normalized Difference Vegetation Index (NDVI)
- Soil classification (SSURGO)
- eCognition geographic objects

Wetland Mapping

Exercise steps are representative of the research but streamlined:

- Ex. 1: Create Normalized Difference Vegetation Index (NDVI) from the 2008 NAIP imagery
- Ex. 2: Create Compound Topographic Index (CTI) from provided slope and specific catchment area data, combine with NDVI and with soil classification to create a preliminary wetland map
- Ex. 3: Use the above map with image objects to create a refined wetland map

NDVI Creation

What is NDVI? (Normalized Difference Vegetation Index

- Indicator of "greenness" (e.g. vegetation)
- Values < 0   Water
- Values 0 < .1   Barren, rock, soil
- Values .1 < .3 Shrub Grassland
- Values .6 - .8   Indicate dense vegetation
- NDVI = (NIR – Red)/ (NIR + Red)

  where the NIR is the near infrared band of imagery and Red is the red band

Exercise 1

You'll create an NDVI raster from NAIP imagery provided of the study site in Chanhassen

Note: In ArcMap 10 there is a reported intermittent bug specific to the calculation of NDVI. If it appears for our configuration of computers it will create a raster that is all zeroes (black)

Take some time to explore the image and web links provided

Exercise 1

CTI Creation

What is the CTI? (Compound Topographic Index)

- Indicator of potential saturated and unsaturated areas within a catchment area (e.g. a watershed)
- Function of the Specific Catchment Area and the slope of the landscape
- CTI = ln [(As)/ (Tan (β)]

where the natural log (ln) of the ratio of the Specific Catchment Area (As) is expressed as m² per unit width orthogonal to the flow direction, divided by the tangent of the slope (β)

Tools Available for CTI Creation

There are several toolsets that can be used to create the CTI layer

- ArcHydro extension
  - Available from ESRI
- TauDEM (Terrain Analysis using Digital Elevation Models)
  - Fully Compatible with ArcGIS 9.3.1
  - Works only with ArcGIS 10 command line-no GUI
- Whitebox
- SAGA
- Landserf

CTI Creation –GIS Steps

DEM Reconditioning (AgreeDEM) – Adjusts the DEM by imposing linear features (streams, ditches, etc.) This is done in ArcGIS using the DEM Manipulation > DEM Reconditioning menu choices

Fill Sinks (Fill) –DEM processed to eliminate elevation irregularities that could interfere with the correct hydrologic flow. DEM Manipulation > Fill Sinks

CTI Creation – GIS Steps (Cont)

Flow Direction – D8 Algorithm uses eight discrete flow angles into each raster cell and a single output flow.

Three step process in Arc Hydro:

- Flow Direction (FDR) using the D8
- Calculation of Flow Width
- Reclassify FDR for cell width of 3m

Flow Accumulation - shows for each raster cell, the number of cells contributing runoff into it

CTI Creation – GIS Steps (Cont)

Specific Catchment layer – is a raster grid representing for each cell the upslope contributing area per unit flow width perpendicular to the flow direction

Slope Grid from DEM – a raster representing a change in elevation between adjacent pixels with a minimum value of 0.001 to avoid division by zero. Expressed in radians: (slope in degrees) * (3.14159 / 180)
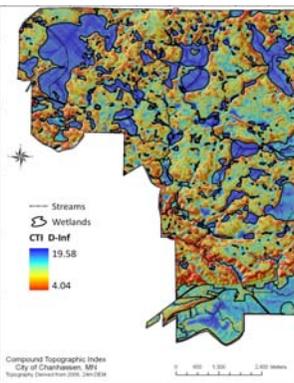
CTI Creation – Final Calculation

Catchment Area (AS) expressed in m² / unit width orthogonal to flow direction

Slope Grid from DEM (ß) expressed in radians

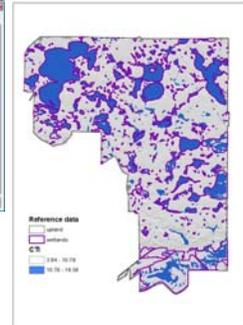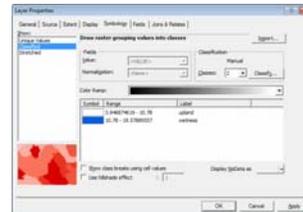$$CTI = \ln\left[\frac{AS}{\tan(\beta)}\right]$$

Notes on CTI Creation

In Exercise 2 we will simplify the above steps by providing you with a pre-generated slope and catchment area. You will create a CTI from this information.

Chanhassen Study Area CTI

CTI Layer Symbolized in ArcMap

Preliminary Classification

We will use the Map Algebra Raster calculator tool to perform the previous calculations

In Arc 9.3.1 this functionality is available within the raster calculator tool bar which went away in Arc 10

Final Processing Steps

We will perform a series of raster algebra steps to process these inputs and create a final map of wetland classification:

- Reclassify the input rasters – at the end of exercises 1 and 2 our final step was to reclassify the CTI and NDVI rasters to either a value of
  - ○ 0 ➔ Not likely wetland
  - ○ 1 ➔ Possibly wetland

Wetland Classification
with Raster Calculator
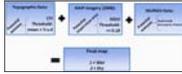
Exercise 2
Followed by Break

Wetland Classification

Several approaches are viable:

- Use Object Based Image Analysis tool such as eCognition to segment the area and apply rules to classify the segments
- Use pixel based classifier such as ERDAS 2011
- Use ArcGIS raster calculator to assign classes to raster cells based on formula values

The MN NWI update is using a combination of an object based approach and decision tree models.

Exercise 3

In Exercise 3 you will classify geographic objects (groups of pixels) into one of two classes, wetland or upland, based on your wetland classification, a NAIP image, and your knowledge.

Exercise 3

Some Final Comments

Pixel based classifiers with map algebra can be an effective, low cost way to map wetlands with available LiDAR, NAIP and soil information

Object-based classifiers like eCognition take advantage of patterns on the landscape.

The University of Minnesota Remote Sensing Geospatial Analysis Laboratory is investigating these and other wetland mapping techniques.