Abstract

Using Terrain Data to Identify Potential Vernal Pools in Urban Locations (Portland, OR)

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Keywords: amphibian habitat, digital elevation model, stochastic depression analysis, surface depression, terrain model, topographic depression, vernal pool, urban

Calls are heard from urbanized stormwater retention ponds, and backyards in Portland during the late winter breeding season for Northern Red-legged frogs and Western Chorus frogs [1,2,3,4,5]. Natural terrain features are regarded as the main contributors to metapopulation dynamics and amphibian species survival, but ground surveying is a costly endeavor and private land may be off limits. [6,7,8]. 1-meter LiDAR bare earth DEM and 0.5 ft four-band orthoimagery (leaf-off) were used determine potential vernal pools (PVPs). Topographic tools in ArcMap 10.6 and Whitebox 3.4 packages may identify depressions differently. We adapted the methodologies for surface depression identification criteria and PVP classification. Low depth (-19 ft to 0 ft), low vegetated pools support tadpoles, but depression criteria are difficult to identify. We selected pools using thresholds: water depths >0.5 ft., areas >120 sq ft., and verified water using NDWI. Three urban areas (industrial, residential, parks) differed between ArcMap and Whitebox [9]. Smaller, open canopy pools benefit from the stochastic depression analysis tool (Whitebox 3.4). Larger, open pools were successfully identified, whereas small highly vegetated pools may have reduced depression elevation and were not identified. Whitebox pools appeared as smaller depression areas across all sites, but appear as multiple clusters in close proximity especially within residential and industrial areas which may better represent potential breeding site criteria in urban locations. By identifying PVPs with terrain model tools we can better protect urban refugia for frog metapopulations and promote the survival of native species in the face of development, and regional climate change.

Using Terrain Data to Identify Potential Vernal Pools in Urban Locations

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- **Northern Red-legged frog (*Rana aurora*)**

  Western Chorus frog (*Pseudacris triseriata*)

- **Identifying surface depressions for vernal pools**

  Depth > 0.5 ft

  Area ~ 120 sq. ft area

  Contains water max NDWI of > 0.3, average NDWI of > -0.15 (Wu et al. 2009)

- **Compare ArcMap 10.6 sink and fill tools**

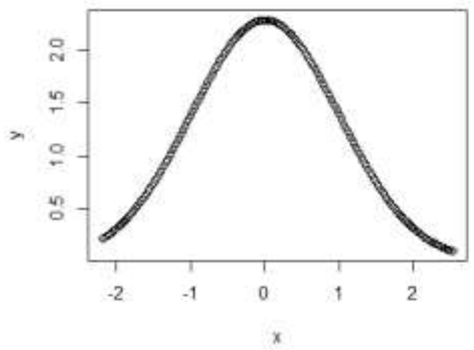
  Whitebox 3.4 stochastic depression analysis tools

Step 1. Using the *Stochastic Depression Analysis tool* in Whitebox, and the *Sink, fill and raster calculator tool* in ArcMap, we will identify surface depressions from bare-earth (first return DEM at 1 m resolution). We will then use ArcMap *Region Group tool* to group depression pixels as objects and convert these uniquely identified depressions to vector format.

Step 2. Multi spectral orthoimagery will be used to calculate the *Normalized Difference Water Index NDWI*.
Zonal statistics will then calculated the NDWI max and NDWI average for each depression.
We will define vernal pools as depressions that have a max NDWI of >0.3 and an average NDWI of >-0.15. [9]
The *overlay toolset* will be used to eliminate depressions that don't meet this criteria for containing water.

Step 3. This results from steps 1-3 will give us a layer of polygons representing potential vernal pools.

Stochastic Depression Analysis: uses Monte Carlo multiple iterations and Gaussian normalized distribution derived from DEM



Types of Urban Sites with Frogs

Industrial-natural
(Reed college area)

Forested-natural
(Butler Creek Elementary School)

Open-natural
(Oaks Bottom)

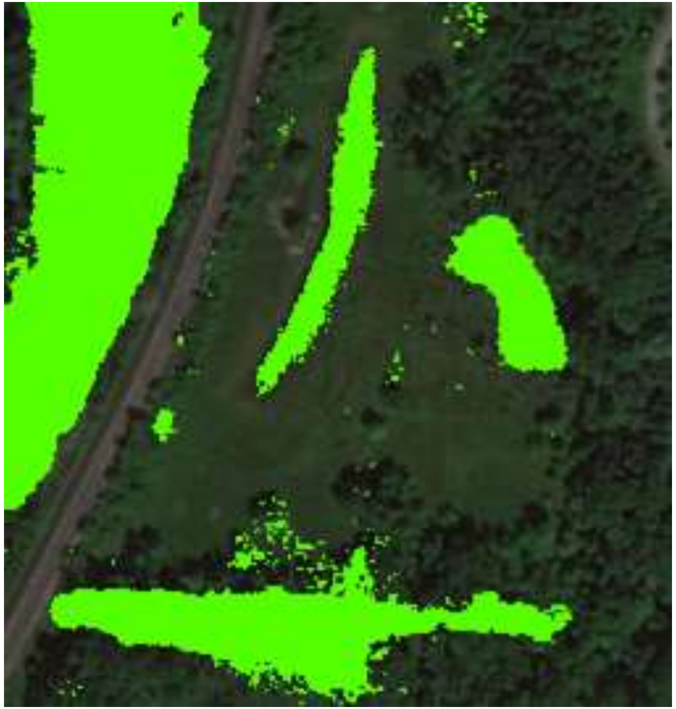
ArcMap 10.6	Whitebox 3.4
Pre-designed tools	Open source, parallels for intensive processing, scripting
Sink & Fill tool	Stochastic Depression Analysis tool
Specify threshold ‘select by attributes’ to find surface depressions	Uses Gaussian distribution histogram and Monte Carlo multiple iterations to find surface depressions
Compatible with base layers water, aerial, DEM	.dep format, import back to Arc for best viewing, very slowwwww

Depressions

Left: ArcMap 10.6
Original DEM - Fill DEM

Right: Whitebox 3.4

Green=
surface depressions



Depression Selection

Convert depression rasters into depression polygons

-Con tool to reclass to 0 or 1 (**depth <-0.5 ft** for Arcmap,
50 iterations for Whitebox)

-Region Group Tool

-Use Con tool to Select Regions > 100 pixels, < background pixels

-Region Group Tool

-Raster to Polygon Tool

-Eliminate Polygon Parts

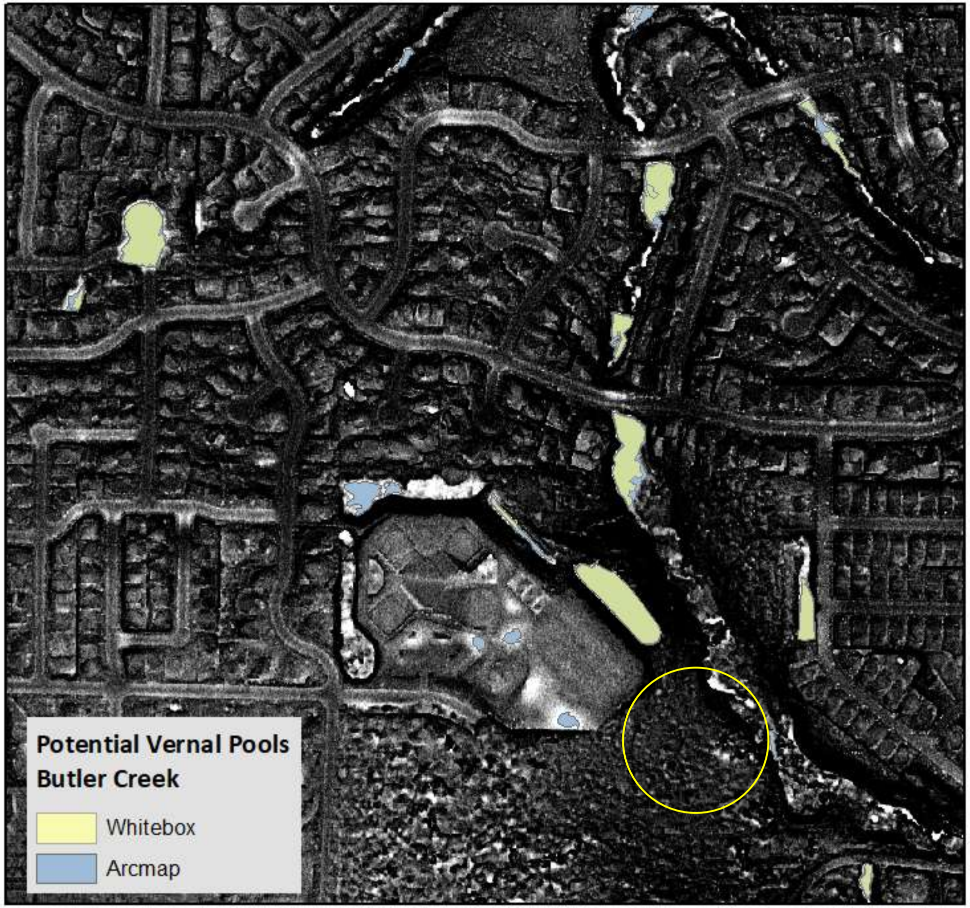
-Select by **area > 100 ft^2**

Residential-natural

(Butler Creek)

Both tools *did not identify* known frog vernal pool

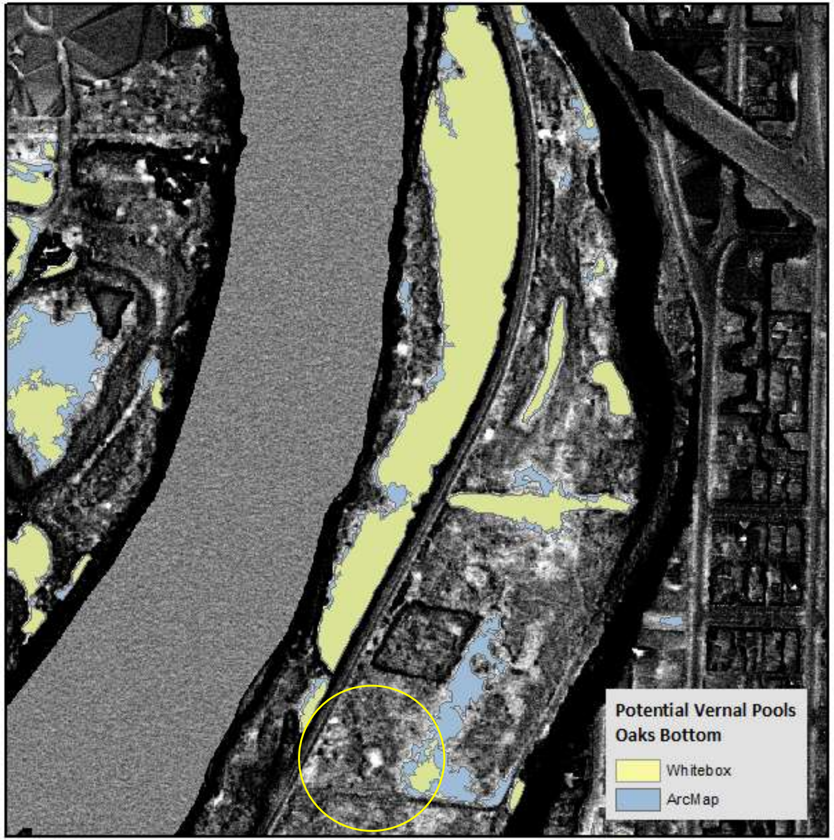
Emergent vegetation may mask depression (increase depression height)



Parks-natural (Oaks Bottom)

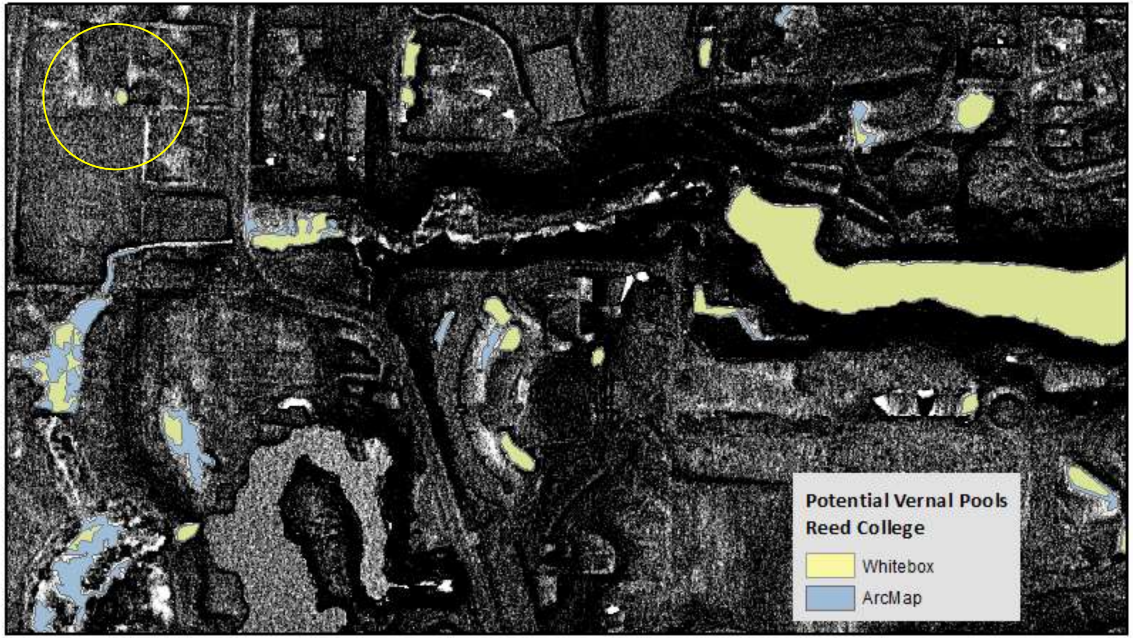
Both tools *did not identify* all known amphibian frog habitat, vernal and permanent

Large, open space, vegetated, connective pools



Industrial-natural (Reed College)

Both tools *identified* known Amphibian pond habitat



Conclusions from Depression Selection

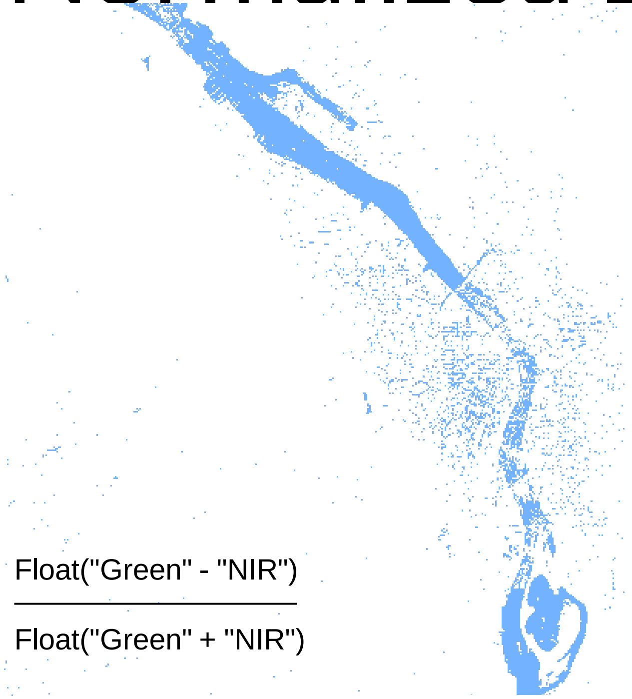
-Whitebox and ArcGIS generated very similar depression. This is likely because the errors in the input DEMs were minimal.

-Generally speaking, WhiteBox generated fewer, smaller, more defined depressions than ArcGIS. However, this is dependent on the classification parameters.

-Both tools missed some known depressions in wooded regions

-For these reasons, the WhiteBox generated depressions were used for all further analysis

Water Verification using Normalized Difference Water Index



$$\frac{\text{Float("Green" - "NIR")}}{\text{Float("Green" + "NIR")}}$$

Positive NDWI (+1) indicated highly reflective surfaces like water, threshold set at verified pools

Whitebox results: Use zonal statistics to calculate average and max NDWI of depressions

Select by (Wu et al. 2009):

-Average NDWI >-0.15

-Max NDWI >0.3

...or as appropriate for site

Butler Creek

Literature Parameters:

Mean NDWI >-0.15: 2/9
Max NDWI >0.3: 0/9
Both: 0/15

Correct: 0
Incorrect: 0
Missed: 0

Our Parameters:

Mean NDWI >-0.35: 5/9
Max NDWI >0.2: 1/9
Both: 1/9

Correct: 1
Incorrect: 0
Missed: 0

Butler Creek

Oaks Bottom

Literature Parameters:

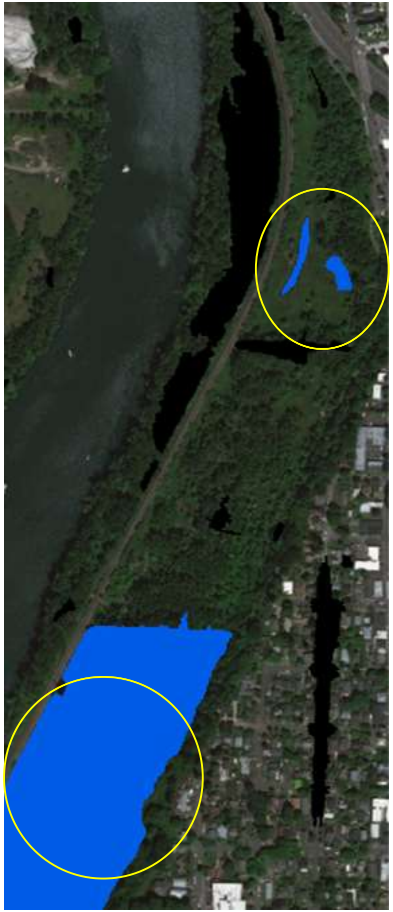
Mean NDWI >-0.15: 6/15
Max NDWI >0.3: 0/15
Both: 0/15

Correct: 0
Incorrect: 0
Missed: 0

Our parameters:

Mean NDWI >-0.35: 8/15
Max NDWI >0.2: 7/22
Both: 7/15

Correct: 3
Incorrect: 0
Missed: 0



Reed

Literature Parameters:

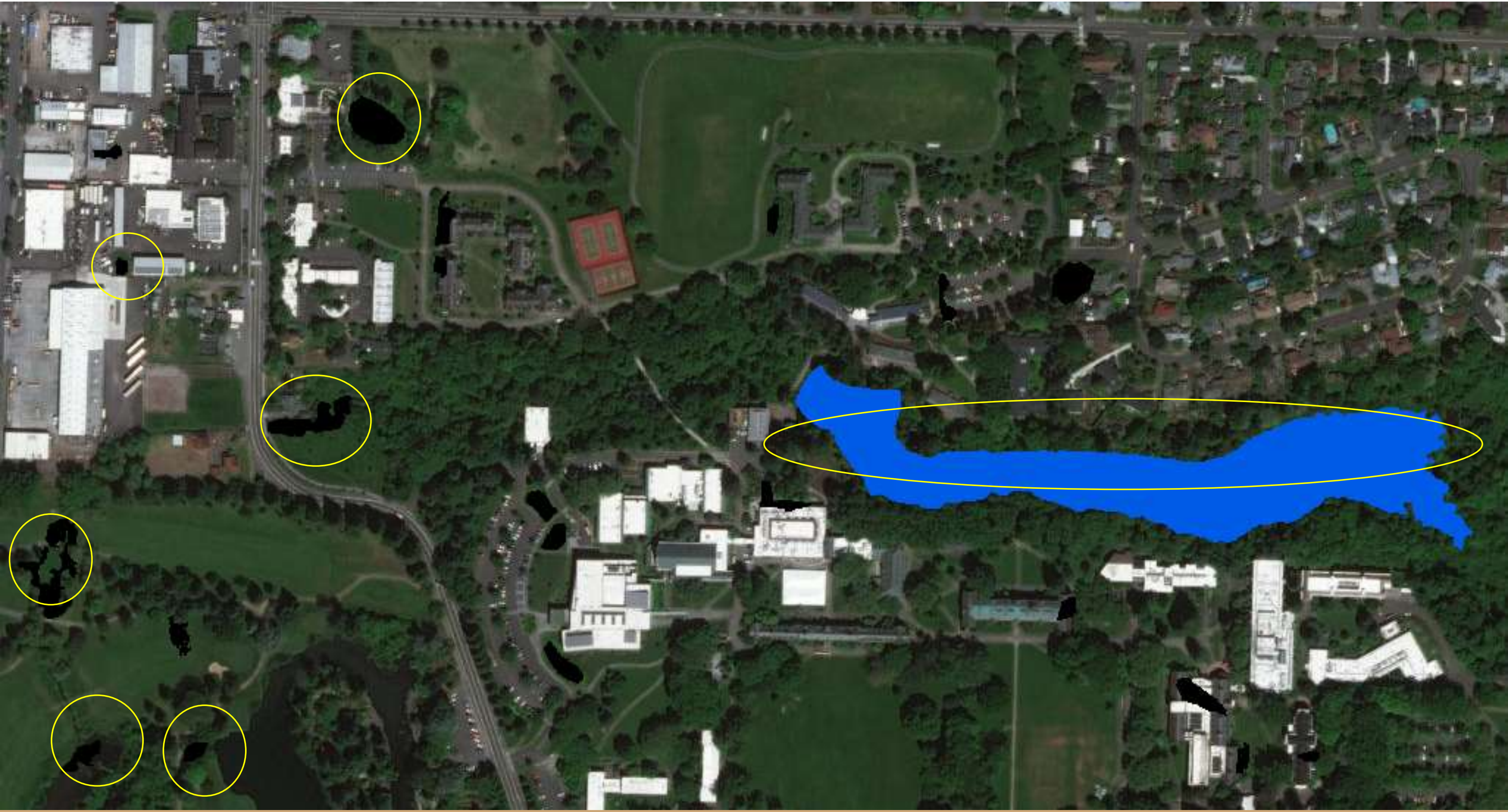
Mean NDWI >-0.15: 11/22
Max NDWI >0.3: 1/22
Both: 1/22

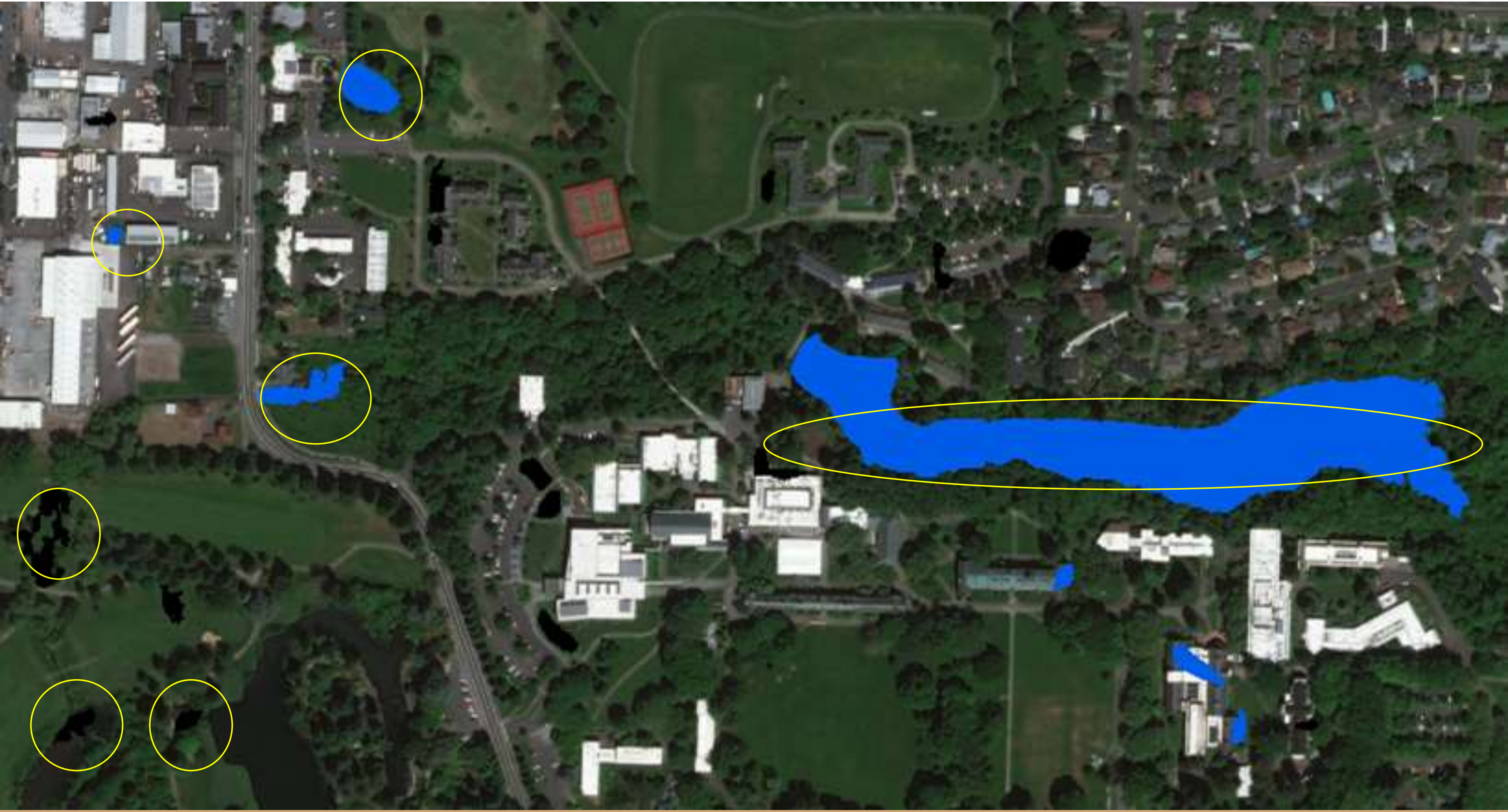
Correct: 1
Incorrect: 0
Missed: 6

Our parameters:

Mean NDWI >-0.35: 18/22
Max NDWI >0.2: 13/22
Both: 11/22

Correct: 4
Incorrect: 3
Missed: 3



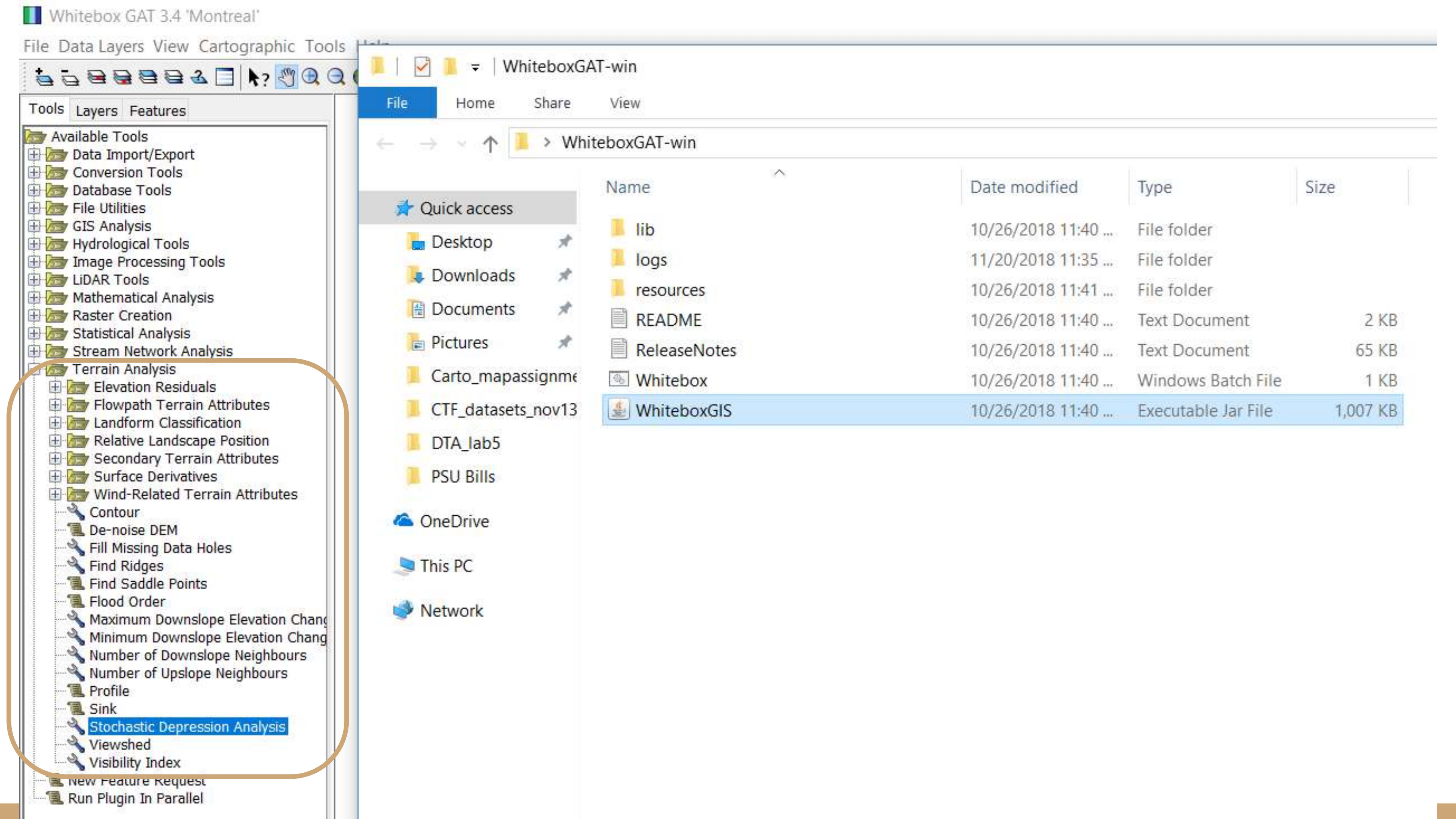


Conclusions from NDWI

- Highly reflective surfaces still can be misidentified with water

- Highly vegetated areas may infringe on the edges of depressions, lowering the NDWI

- Smaller pools tended to have a lower NDWI


Whitebox GAT 3.4 'Montreal'
File Data Layers View Cartographic Tools
Tools Layers Features
Available Tools
Data Import/Export
Conversion Tools
Database Tools
File Utilities
GIS Analysis
Hydrological Tools
Image Processing Tools
LiDAR Tools
Mathematical Analysis
Raster Creation
Statistical Analysis
Stream Network Analysis
Terrain Analysis
Elevation Residuals
Flowpath Terrain Attributes
Landform Classification
Relative Landscape Position
Secondary Terrain Attributes
Surface Derivatives
Wind-Related Terrain Attributes
Contour
De-noise DEM
Fill Missing Data Holes
Find Ridges
Find Saddle Points
Flood Order
Maximum Downslope Elevation Chang
Minimum Downslope Elevation Chang
Number of Downslope Neighbours
Number of Upslope Neighbours
Profile
Sink
Stochastic Depression Analysis
Viewshed
Visibility Index
New Feature Request
Run Plugin In Parallel
WhiteboxGAT-win
File Home Share View
WhiteboxGAT-win
Quick access
Desktop
Downloads
Documents
Pictures
Carto_mapassignme
CTF_datasets_nov13
DTA_lab5
PSU Bills
OneDrive
This PC
Network
Name Date modified Type Size
lib 10/26/2018 11:40 ... File folder
logs 11/20/2018 11:35 ... File folder
resources 10/26/2018 11:41 ... File folder
README 10/26/2018 11:40 ... Text Document 2 KB
ReleaseNotes 10/26/2018 11:40 ... Text Document 65 KB
Whitebox 10/26/2018 11:40 ... Windows Batch File 1 KB
WhiteboxGIS 10/26/2018 11:40 ... Executable Jar File 1,007 KB

Data Sets

Data	Resolution	Acquisition dates	Download Access	Application
LiDAR DEM	1 m in City	up to 2014	PSU server or DOGAMI (recent)	Terrain relief, elevation, and feature height
Aerial 4-band (Winter 2012)	0.5 ft multispectral	2009 (leaf off)	RLIS (I://)	Identify water for vernal pools, NDWI Green, NIR (Band 2 - Band 4)/(Band 2 + Band 4)
Aerial Imagery (Summer/Winter)	1 m	2016	RLIS (I://)	more recent photography, remove misclassed vernal pools, identify features or barriers to frog movement
Water features (perrenial or wetlands)	polygons	up to 2016	RLIS (I://)	Validate potential for water on site
Known frog breeding sites within Portland	points	2010-onward	City of Portland/Gresham Dataset dip-netting surveys	set thresholds for predictive vernal pools based on known breeding locations
Frog Movement Model	30 m	2017	Metro Habitat Connectivity Toolkit, subset of model	Overlay on to new DEM to see if vernal pools are preferred habitat

Butler Creek Depressions

Bright Blue:
depressions defined using White Box
-30 in total

Dark Blue: Depressions defined using ArcGis
-40 in total

Yellow Arrow: missing depression

Oaks Bottom Depressions

Bright Blue: depressions defined using White Box
-46 in total

Dark Blue: Depressions defined using ArcGis
-65 in total

Yellow Arrow: missing depression

Reed Depressions

Bright Blue: depressions defined using White Box
-22 in total

Dark Blue: Depressions defined using ArcGis
-38 in total

References

[1] Fellers, G.M and P.M. Kleeman. 2007. California Red-legged frog (Rana Draytonii) movement and habitat Use: Implications for conservation. *Journal of Herpetology* 41(2): 276- 286.

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[9] Wu, Q., C. Lane and H. Lui. 2009.+ 61(11):1444-11467.

WebSite Links

https://etd.ohiolink.edu/!etd.send_file?accession=ucin1439307917&disposition=inline

https://gis.stackexchange.com/questions/18568/integrating-whitebox-gat-free-and-open-with-arcmap-ui

http://www.uoguelph.ca/~hydrogeo/Whitebox/index.html

https://www.portlandoregon.gov/bes/article/273021

****from online :** exchange raster data between ArcGIS and Whitebox either in ASCII (i.e. text) or binary format. The preferred method is binary because these data are smaller (therefore the import/export operations are quicker) and because it does not significantly alter the original data. The tool for importing ArcGIS rasters is called Import ArcGIS Binary Grid This is the best and easiest way to import raster files from ArcGIS. Floating-point grid files consist of a header file (.hdr) and data files (.flt). The tool can run in batch mode, importing multiple files at one time. Output file names are the same of the input files and are contained within the same directory. Use the ***Raster to Float*** tool in the 'Conversion Tools' toolbox of ArcGIS to create floating-point grid files from your ArcGIS raster files. **We just use a .txt or .asc and it was fine to convert to .dep once imported… but huge file size. So recommend using GeoTIFF instead.**