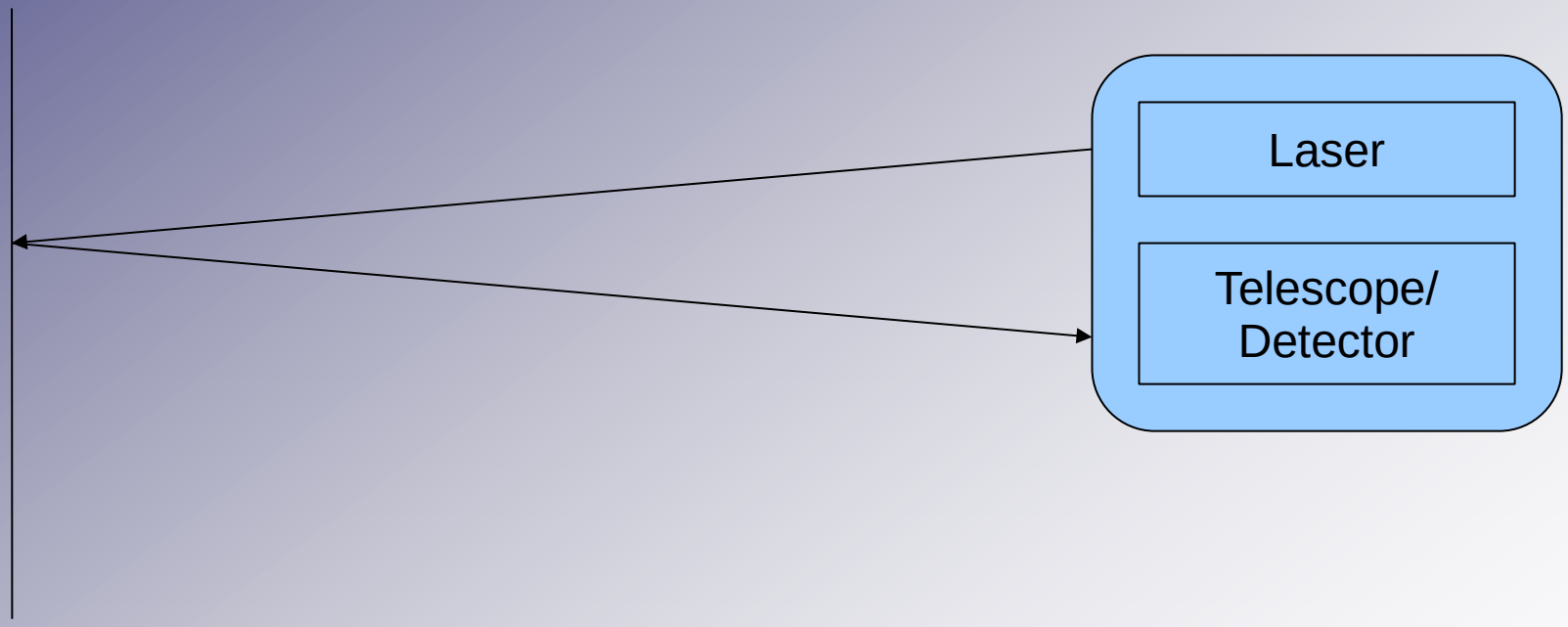
# Quick Introduction to Lidar and Basic Lidar Tools

# What is Lidar

- LIDAR is an Acronym for LIght Detection And Ranging
- A basic lidar device consists of a laser, an optical telescope, and a detector.



# What is Lidar ? - Cont.

- The detector counts the intensity of photons returned over fixed time intervals and these intensities over times are converted to heights called range bins.
- range bin = dz=(c*dt)/2,  where c = the speed of light, dz = distance dt = time. 160 ns would = 24m of dz See http://pcl.physics.uwo.ca/science/lidarintro/ for details.

# Types of Lidar - Lasers

- Lasers can be pulsed or continuous wave, or can be of different frequencies
- Standard airborne lasers will be near - infrared(1047nm, 1064nm, and 1550nm).
- Bathymetric lasers – green (EAARL NOAA/USGS, Commercial)
- Multibeam Lidar – 2 lasers near infrared and Green – mainly coastal, but may become more mainstream.
- http://agrg.cogs.nscc.ca/resources/lidar-glossary

# Types of Lidar – Platforms

- Satellite – mostly profiles
- Fixed-wing aircraft – most common cost-effective
- Helicopter – higher accuracy over large areas and air density/pollutant measurements
- Ground Based – Scan area around point
- Tabletop/vehicle mounted – specialized applications for specific areas.
- 3D scan – place object on rotating surface to scan the object in 3 dimensions

# Posting/Point Spacing Distance

- Distance between successive ground points
- Historic 5-8 Meters  ( NC 2001)
- FEMA Flood standard 1.4 M/ USGS QL2 standard 0.7m posting
- High density 10 points /M
- FEMA requires better reporting/metadata
- http://www.fema.gov/plan/prevent/fhm/lidar_4b.shtm

From http://www.eijournal.com/LiDar_Mapping.asp

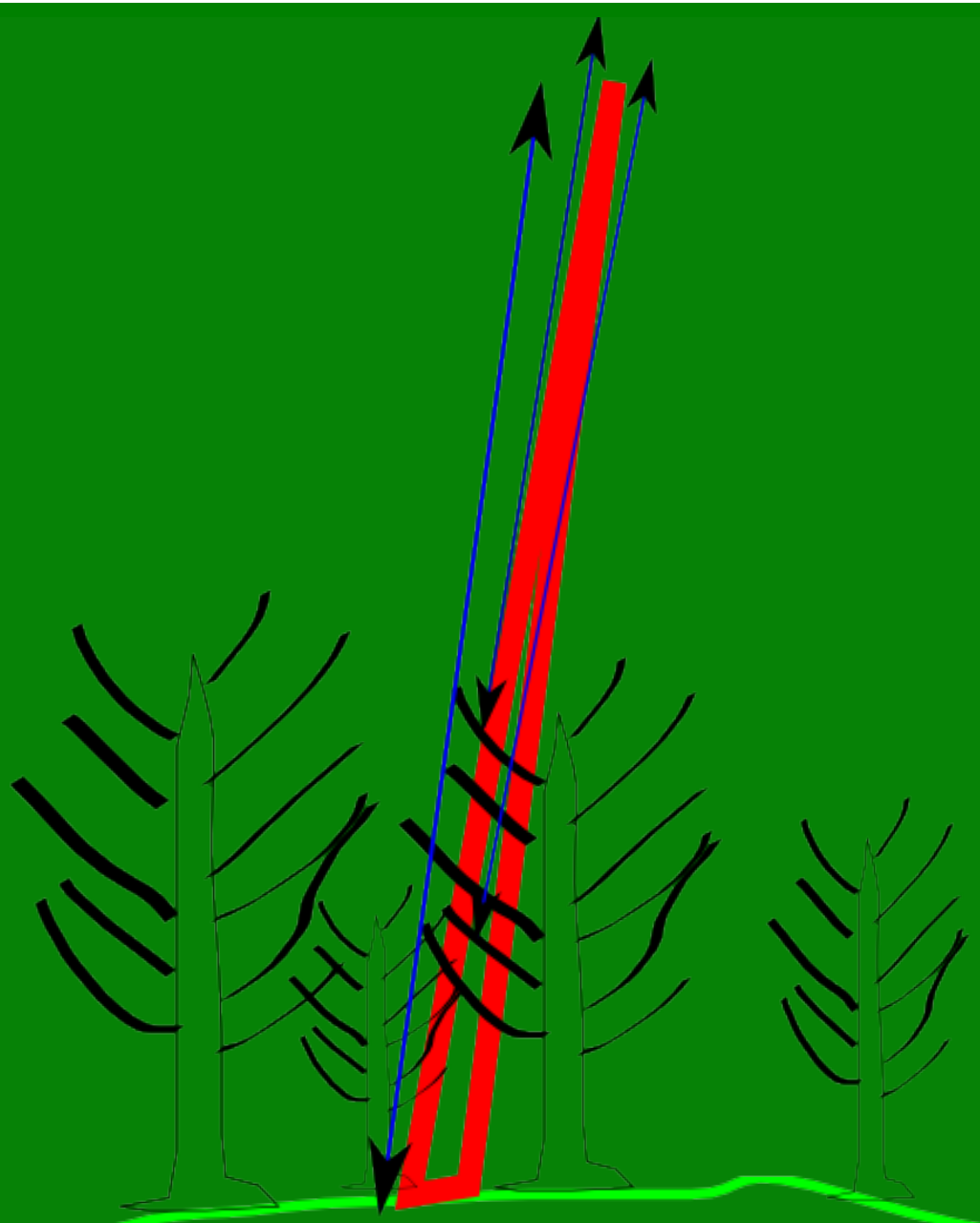
# Lidar data outputs

- Ascii X,Y,Z
- Proprietary binary formats – older data going away ( .ebn, .eebn)
- LAS format -Industry standard, not mandatory, usually not all “required” fields populated. Many lidar “cameras” are generating LAS as the default data output.  Single file size currently limited to 4 billion points. (new version 1.4 supports many more points per file)

# Bare Earth points

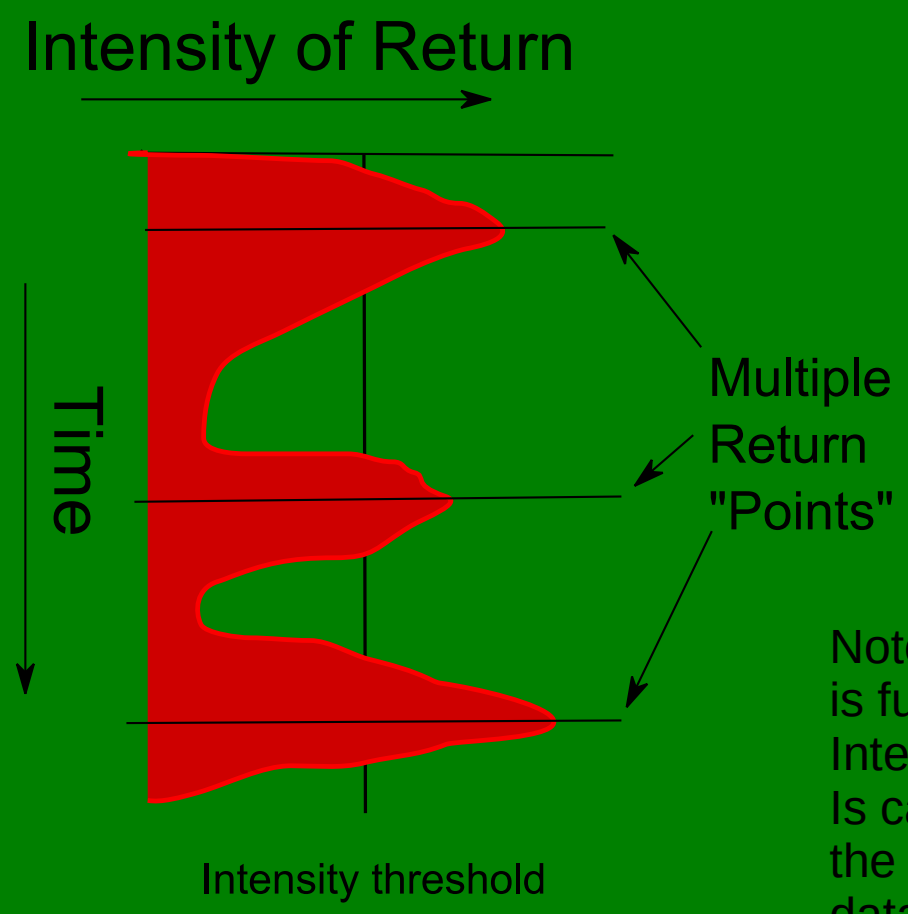
- Points derived from the data cloud believed to represent the ground surface.
- Not easy – Generally leave to the experts. Usually a standard deliverable. Can be done with some free/open source tools. http://grass.fbk.eu/grass64/manuals/html64_user/v.lidar.edgedetection.html.
- MCC-Lidar http://sourceforge.net/apps/trac/mcclidar/

# Lidar Beam Spread and Multiple Returns



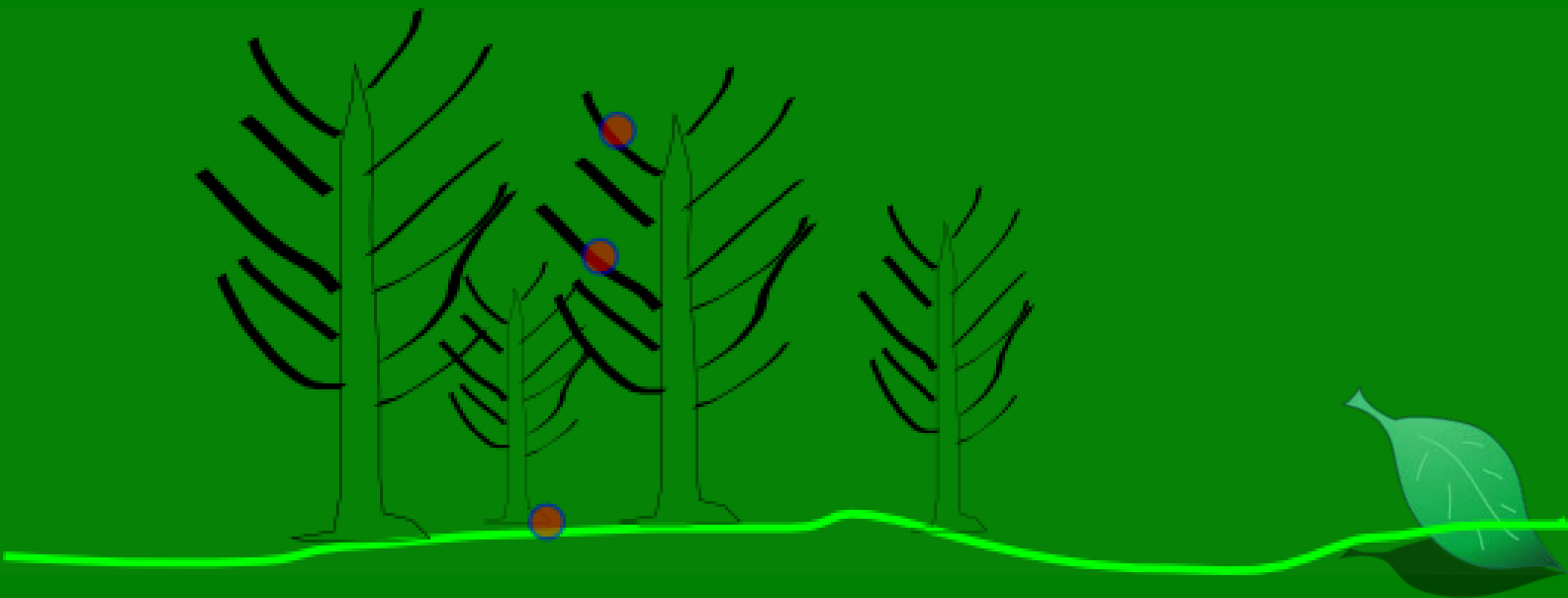
As the light beam travels down to the ground, it spreads out slightly and can encounter obstructions on the way. Power lines, rooftops, and tree branches can all give return reflections. There can be up to 5 returns per light pulse, but 1-3 is more common

# How Multiple Return Points are derived

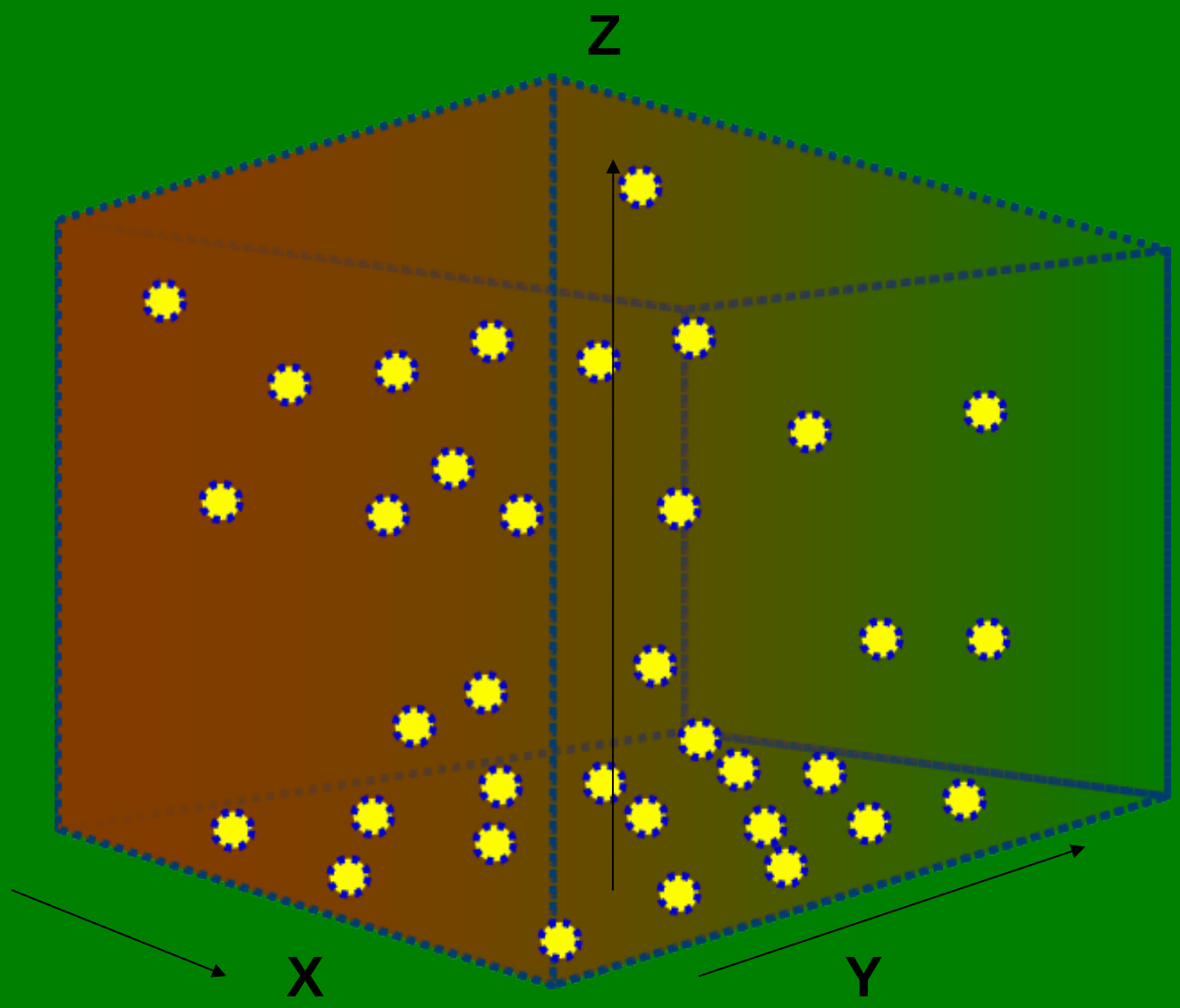



Note that Green laser lidar data is full return. This means that the Intensity of the return for given time slices Is captured. In other words, the graph on the left would have 100 or more data values over the duration of the laser pulse instead of 3.

For every beam/pulse
you end up with an X,Y,Z coordinate
for everything in the beam path



# Lidar Point Cloud

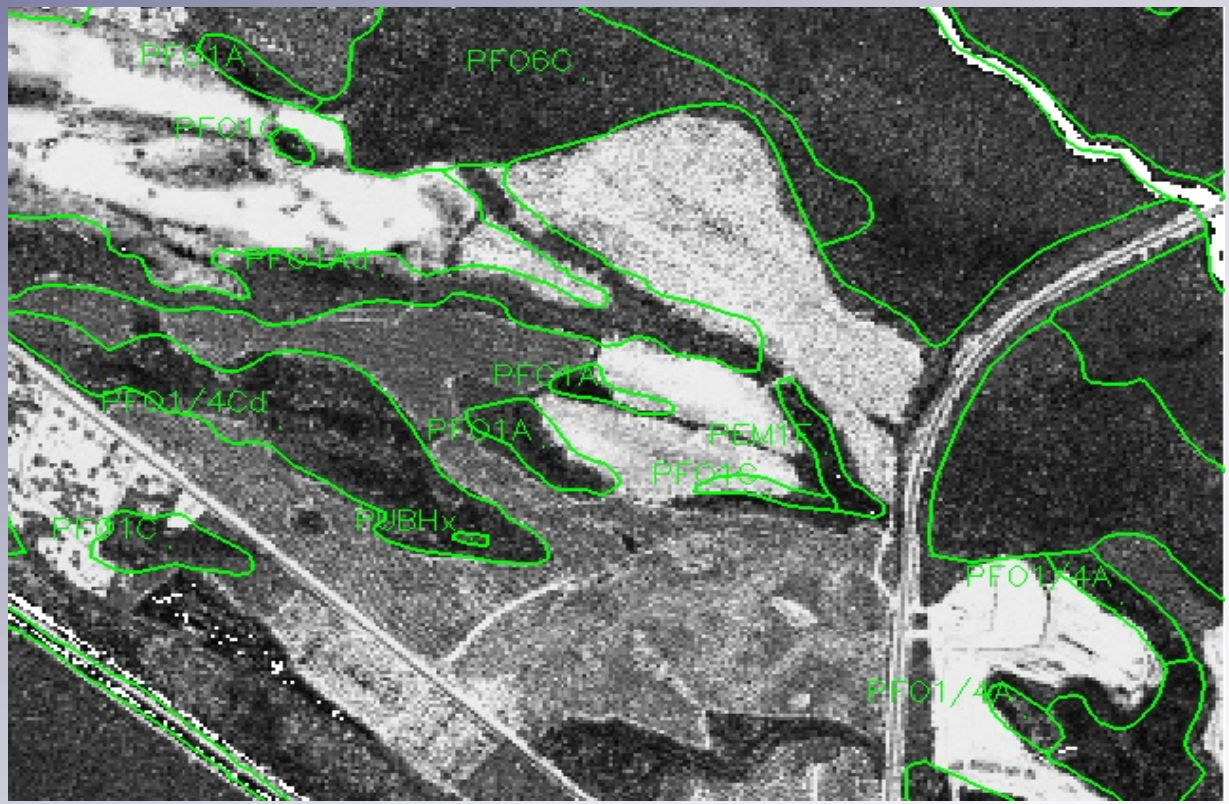


# Return numbers/Return types

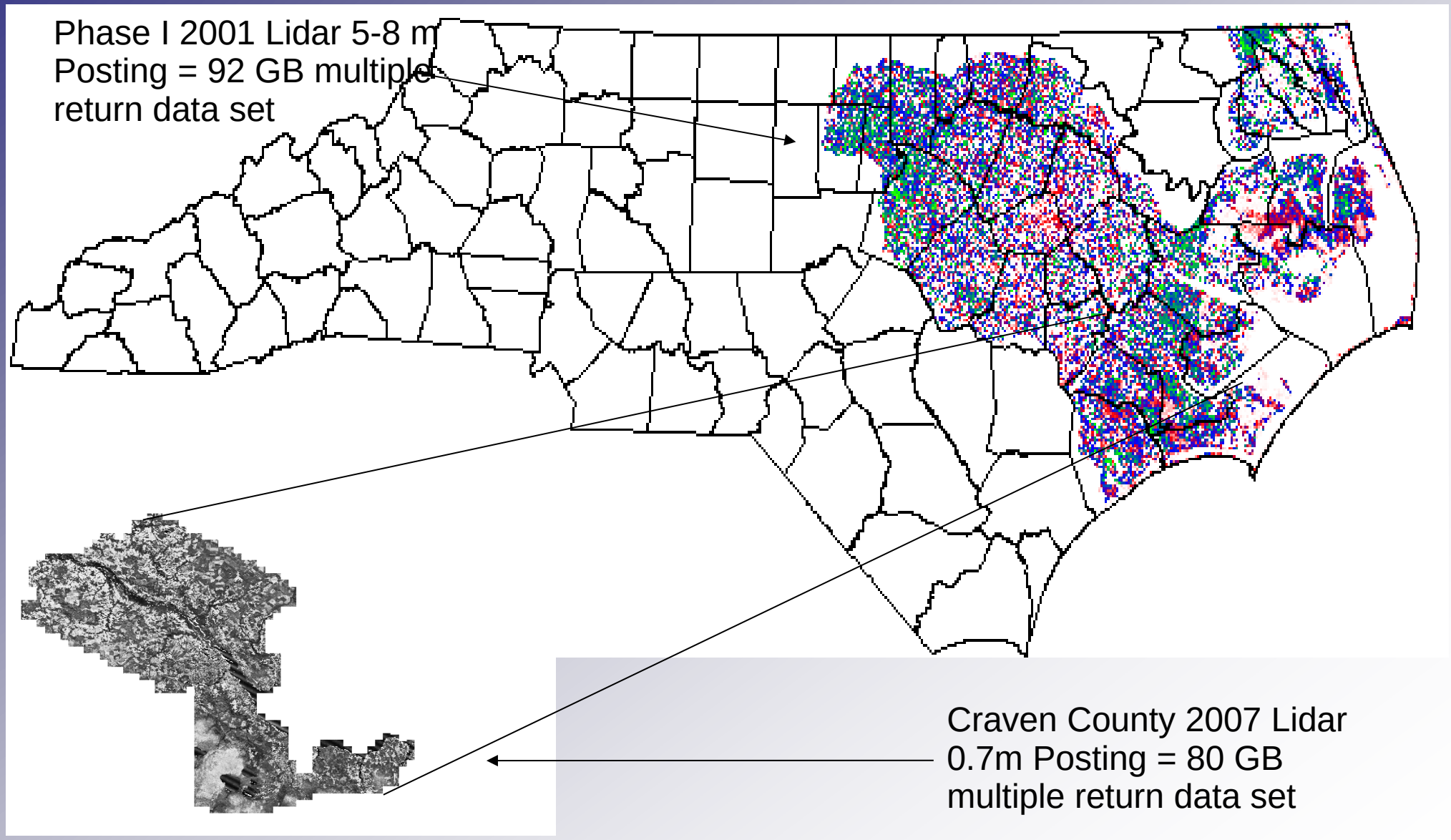
- Multiple returns from the same pulse (can be up to 5, usually not more than 3)
- First of many, second of many, last of many
- First and only
- Not all lidar data sets contain this data :-(
- 1/3 of NC data has no return numbers.  1/2 has no intensities.

# Intensity

- Measure of reflectance of target for each return
- Near infrared frequency lasers sensitive to moisture, chlorophyll.  Possible wetland delineation tool, but is a relative measurement.



# Data Volume increases with resolution



# Nationwide LiDAR Data collection Under Discussion

Table 1.2. The five pre-defined topographic data Quality Levels (QLs)

| Elevation Quality Levels (QL) | Source | Horizontal Resolution Terms | | | Vertical Accuracy Terms | |
|---|---|---|---|---|---|---|
| | | Point Density | Nominal Pulse Spacing (NPS) | DEM Post Spacing | Vertical RMSEz | Equivalent Contour Accuracy |
| QL 1 | LiDAR | 8 pts/m$^2$ | 0.35 m | 1/27 arc-sec ~1 meter | 9.25 cm | 1-ft |
| QL 2 | LiDAR | 2 pts/m$^2$ | 0.7 m | 1/27 arc-sec ~1 meter | 9.25 cm | 1-ft |
| QL 3 | LiDAR | 1 – 0.25 pts/m$^2$ | 1 – 2 m | 1/9 arc-sec ~3 meters | ≤18.5 cm | 2-ft |
| QL 4 | Imagery | 0.04 pts/m$^2$ | 5 m | 1/3 arc-sec ~10 meters | 46.3 cm – 139 cm | 5 – 15 ft |
| QL 5 | IFSAR | 0.04 pts/m$^2$ | 5 m | 1/3 arc-sec ~10 meters | 92.7 cm – 185 cm | 10 – 20 ft |

“standard” resolution proposed Q2 = 0.7m posting

http://www.dewberry.com/Consultants/GeospatialMapping/FinalReport-NationalEnhancedElevationAssessment

# Software Tools

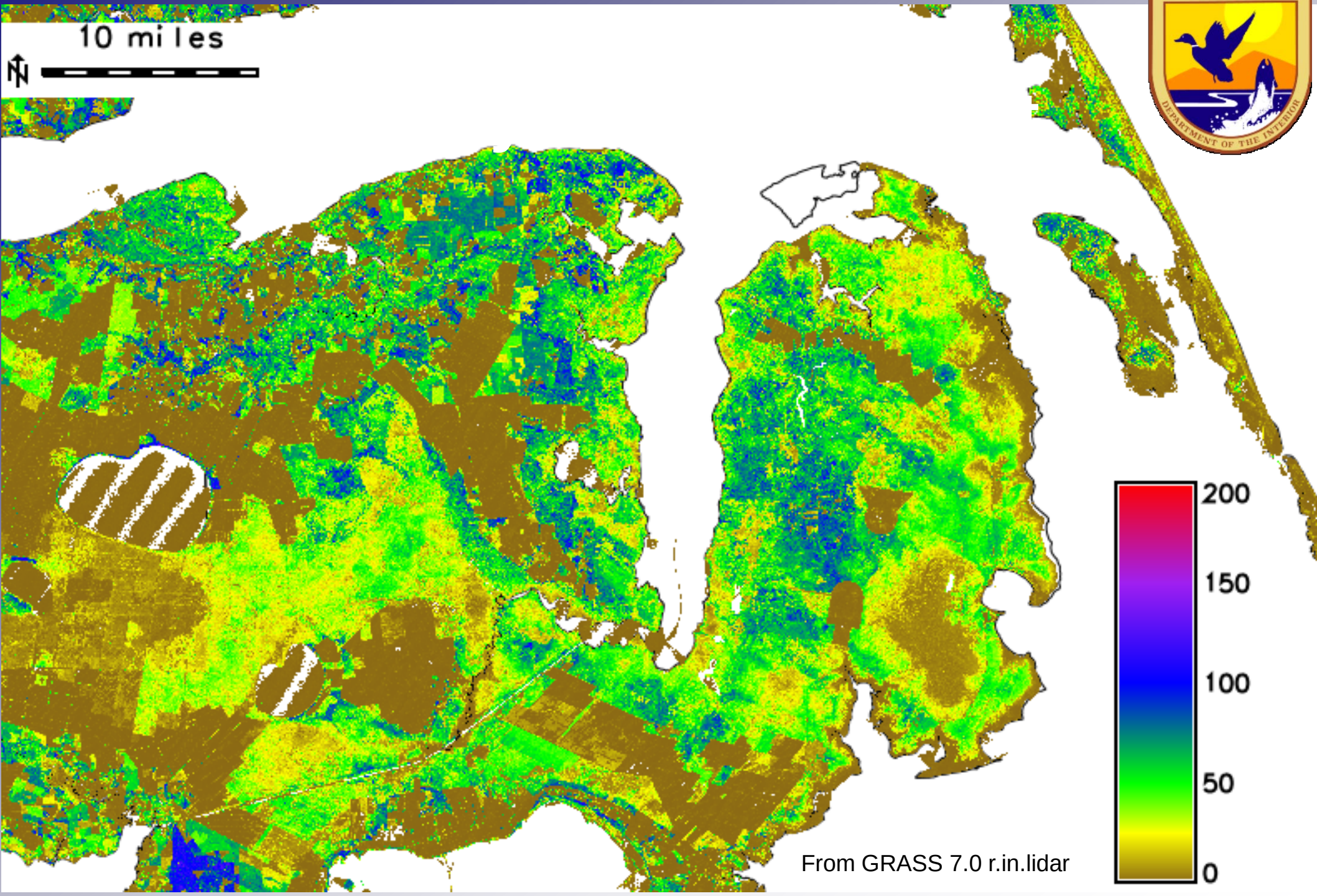
- LP360 plugin for ArcGIS/ERDAS $3000 + 18% per year Maintanence
- LASTools – command line, extraordinarily fast. Some free, some commercial at $1.5K per tool or $4k for the bundle http://www.cs.unc.edu/~isenburg/lastools/
- LASZIP - http://www.laszip.org/ - use from the command line laszip-cli.exe –h for options. Free software under LGPL license
- Fusion LTK – USFS maintained tool for canopy/fuel analysis
- Liblas – http://liblas.org - command line tool for reading,extracting, and manipulating LAS format data.
- Pdal – http://www.pdal.io/ - Successor to Liblas, more generic point cloud formats
- GRASS – Can handle large multiple return data sets
- ArcGIS 10.1 – Can read LAS files, but need to import to Lidar Dataset first to analyze in bulk. Newer versions have .zlas format for Lidar
- Envi LAS modules

# Reprojecting masses of points

- Cs2cs  - command line utility for point coordinate reprojection – part of FWTools utilities
- Liblas – Uses gdal libraries.
- Pdal – uses gdal libraries
- Some Lidar data does not have projection information in the LAS file – read the Metadata.

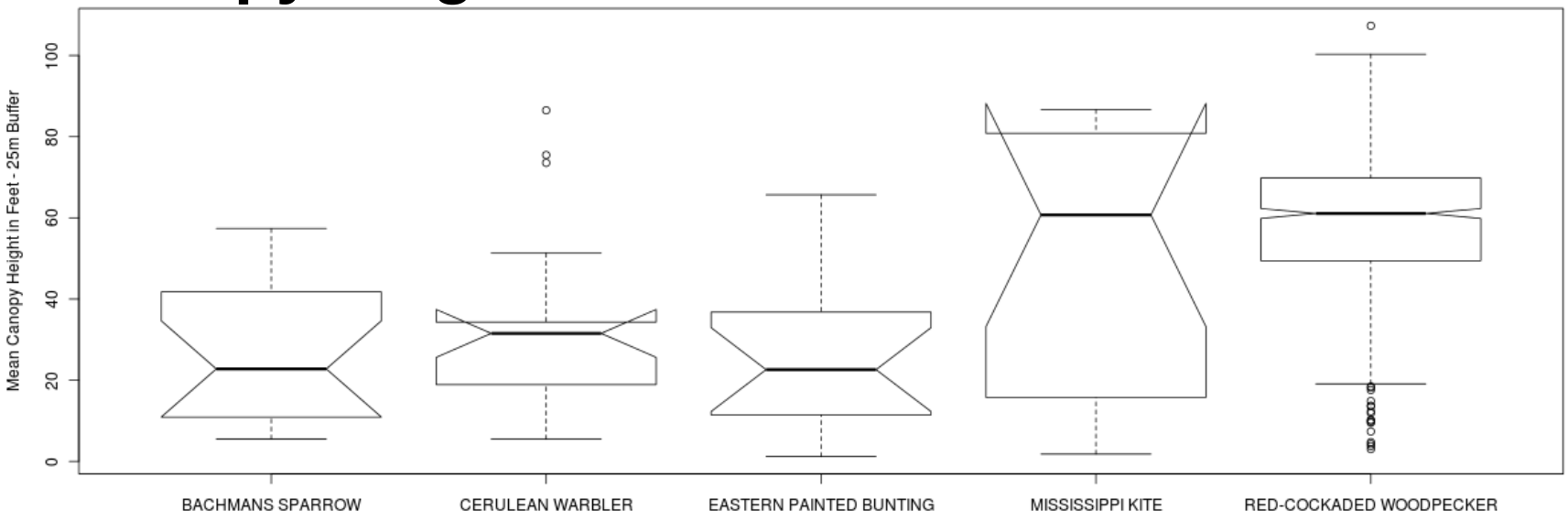
# Fun things you can do with Lidar Data….

# Canopy Heights

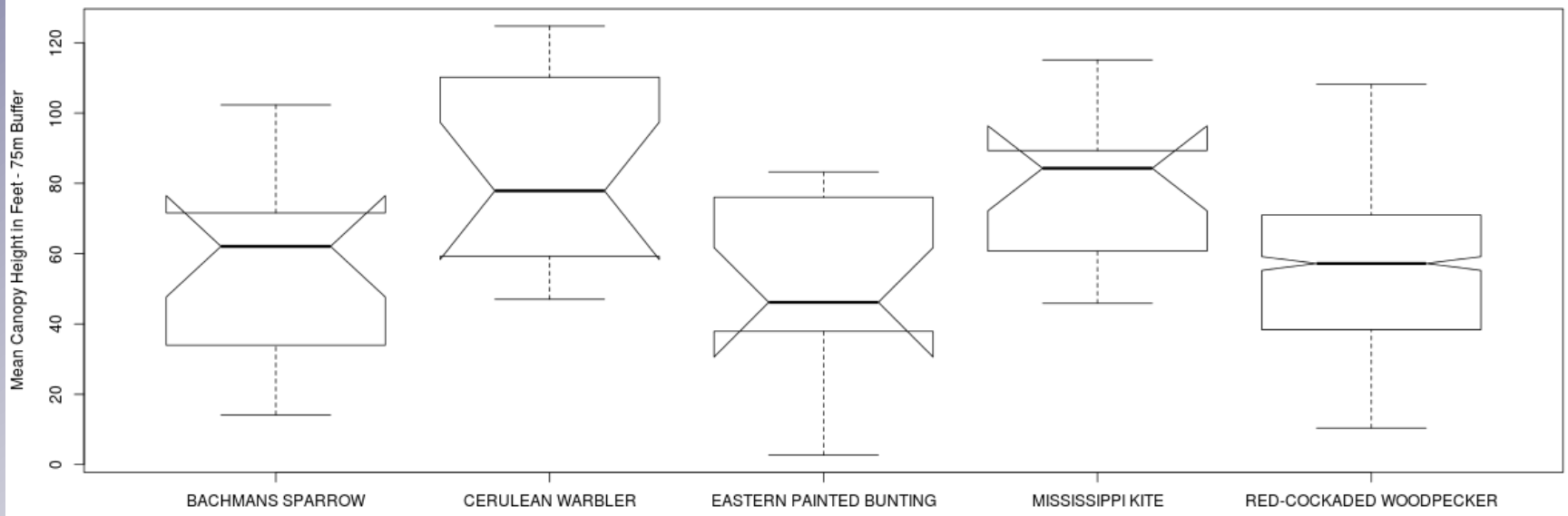



From GRASS 7.0 r.in.lidar

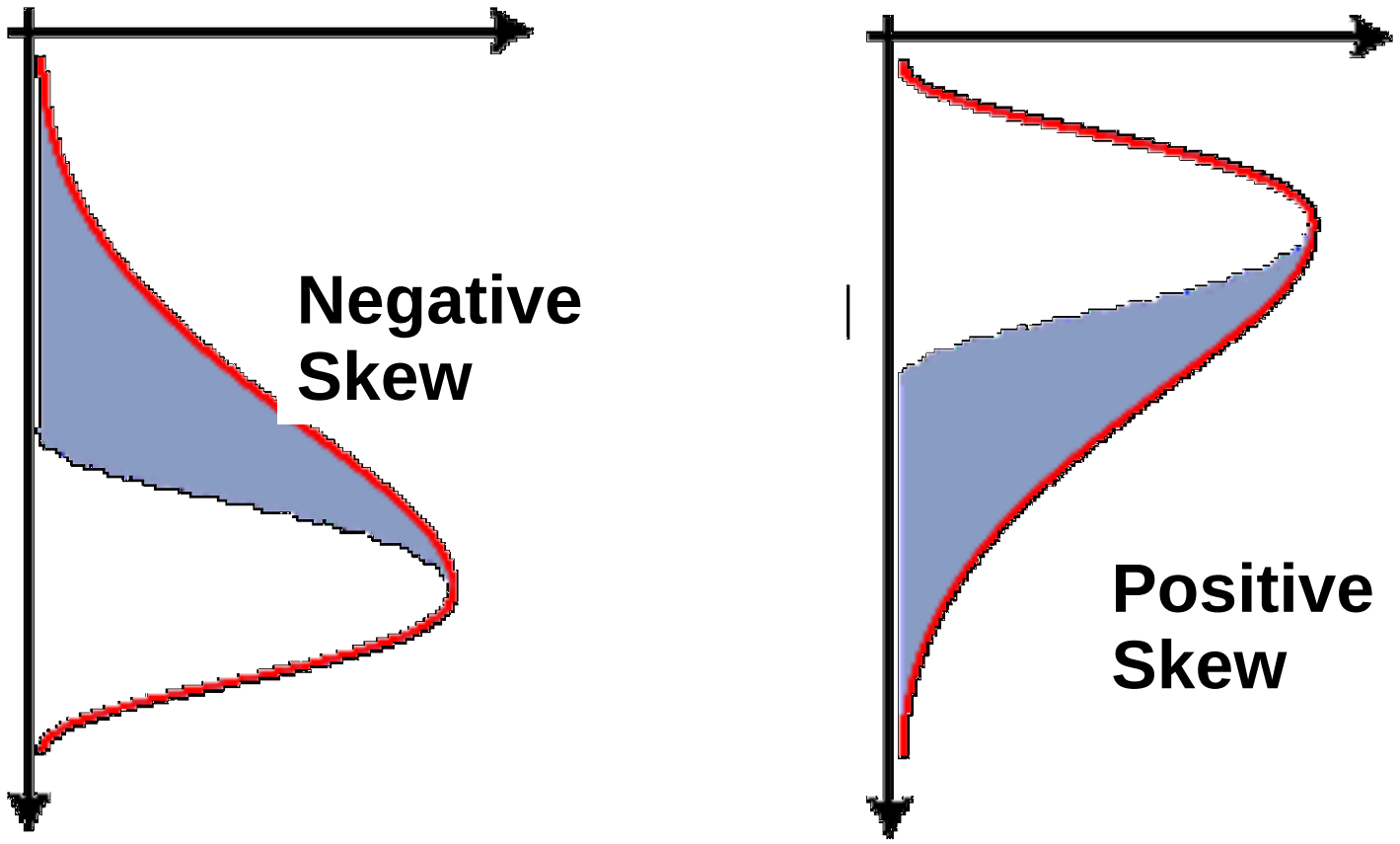
# Canopy heights and bird nests



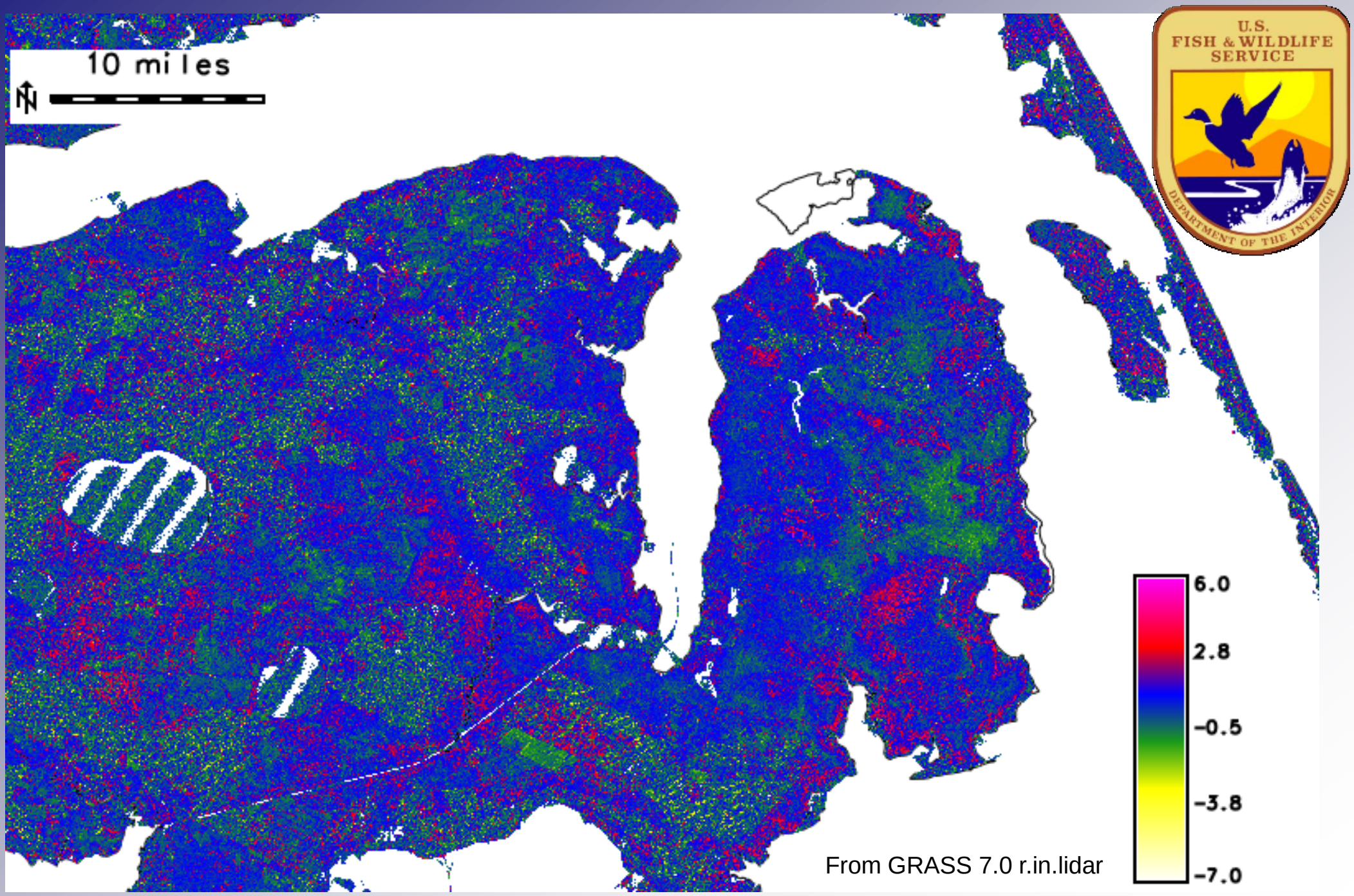

**Mean Height at 75m seems to be washing out differences between species, see RCW and Painted Bunting**



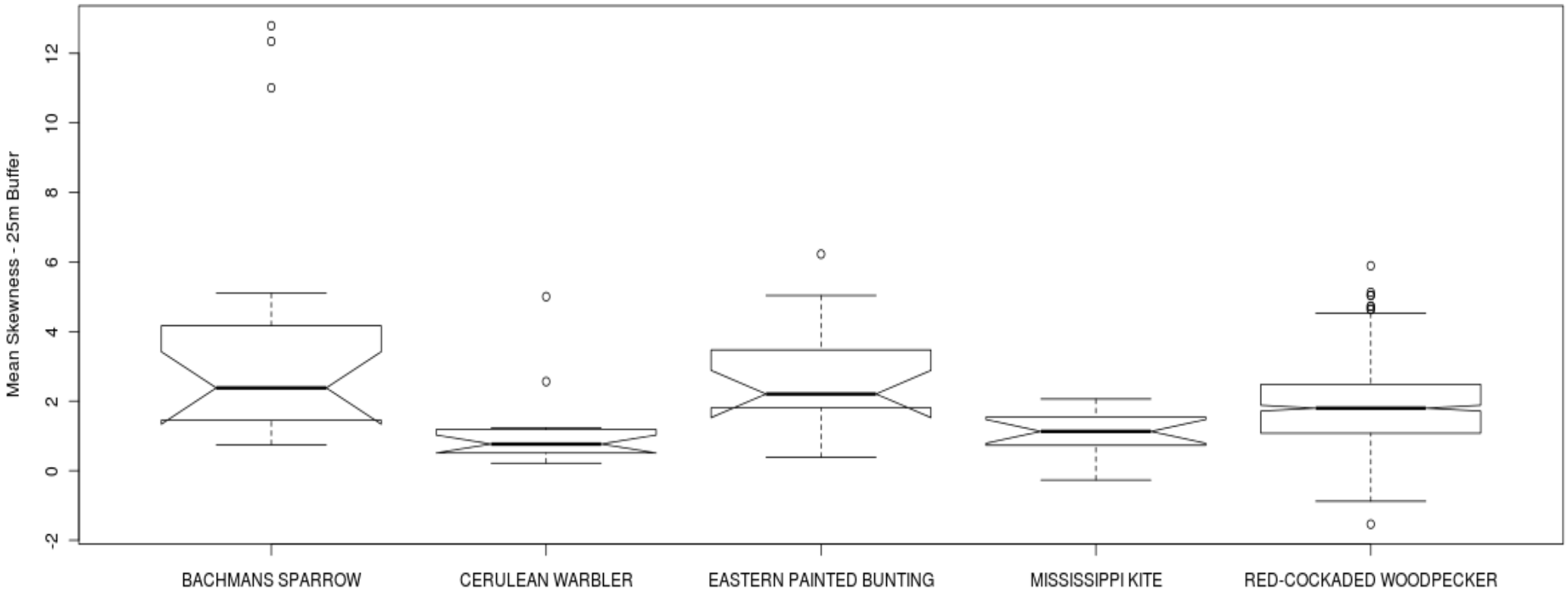
# Skewness of Z values of LiDAR points in each cell.



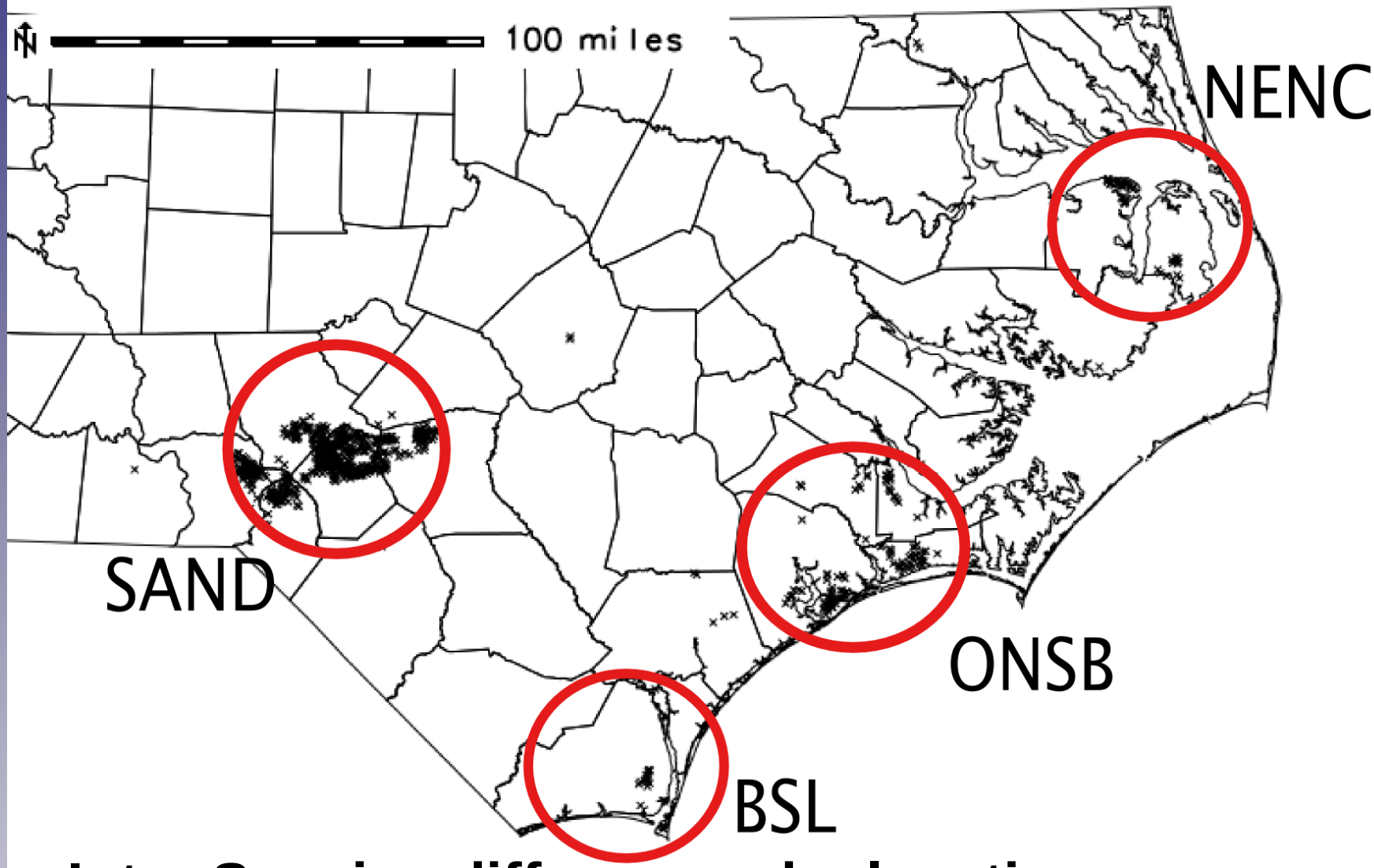
# Skewness of Z values of LiDAR points .



# Skewness at 25m

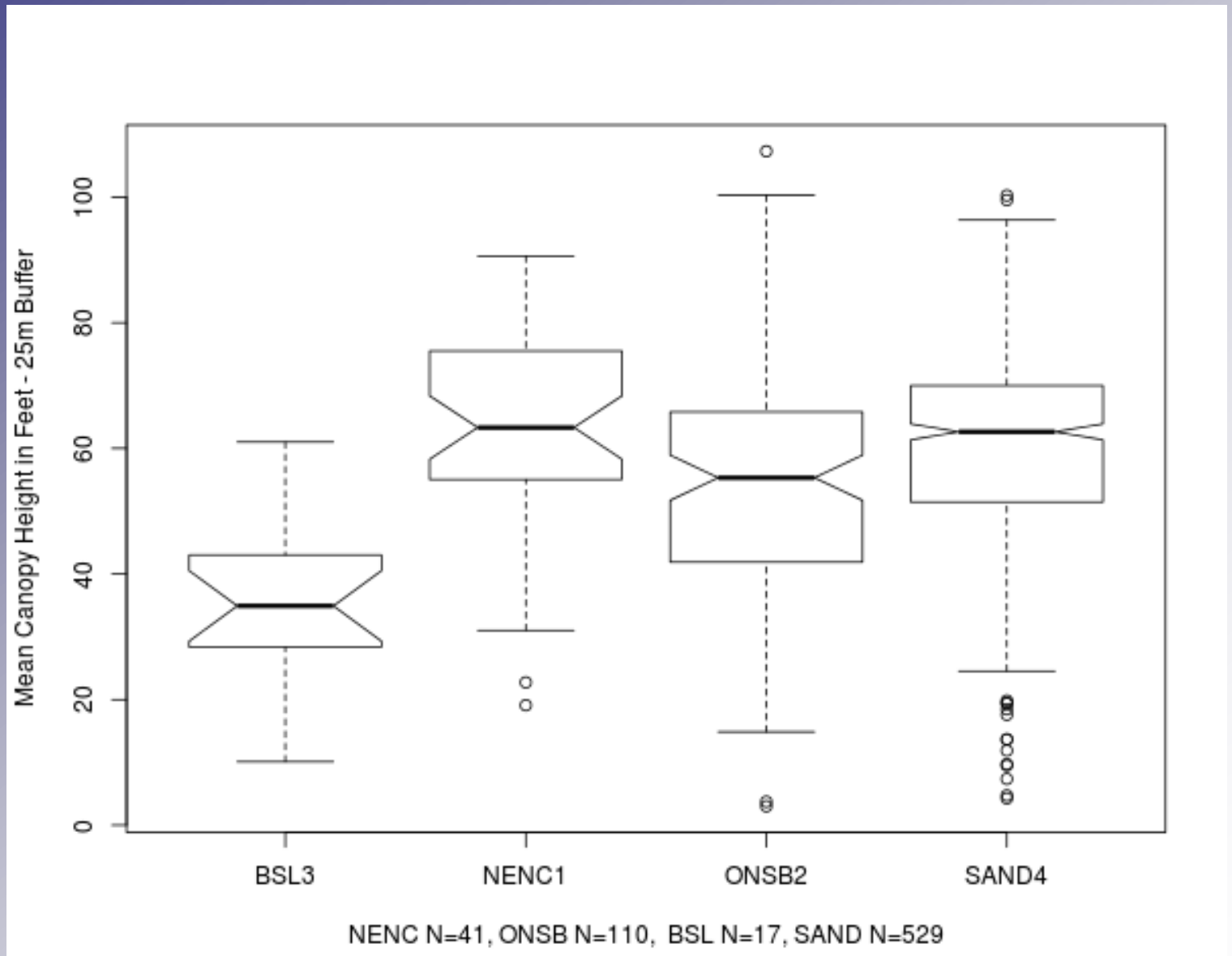


# RCW Populations (1998-2003) in Northeast NC (NENC), Onslow Bight (ONSB), SE NC (BSL), and NC Sandhills (SAND)

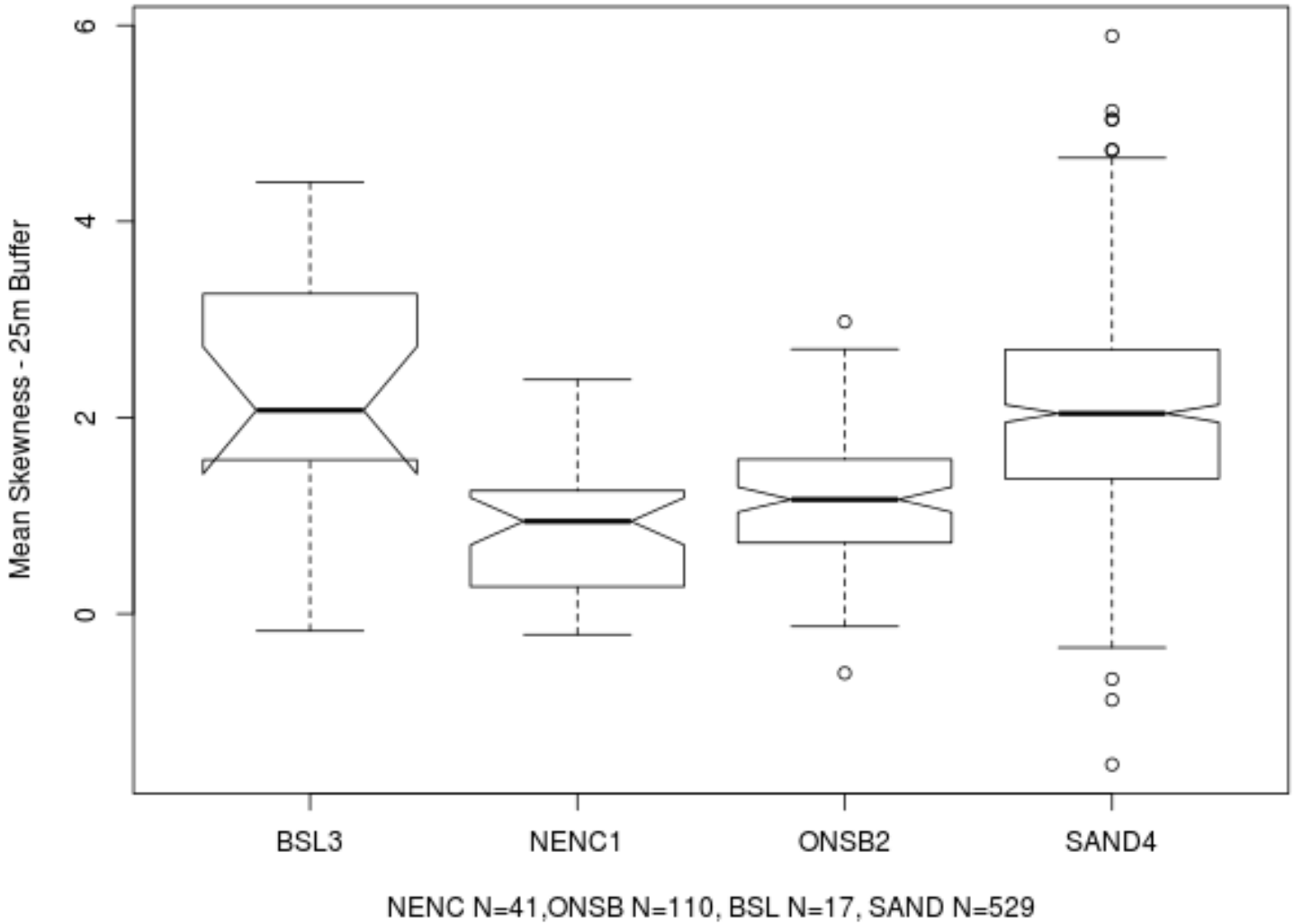



**Intra Species differences by location**

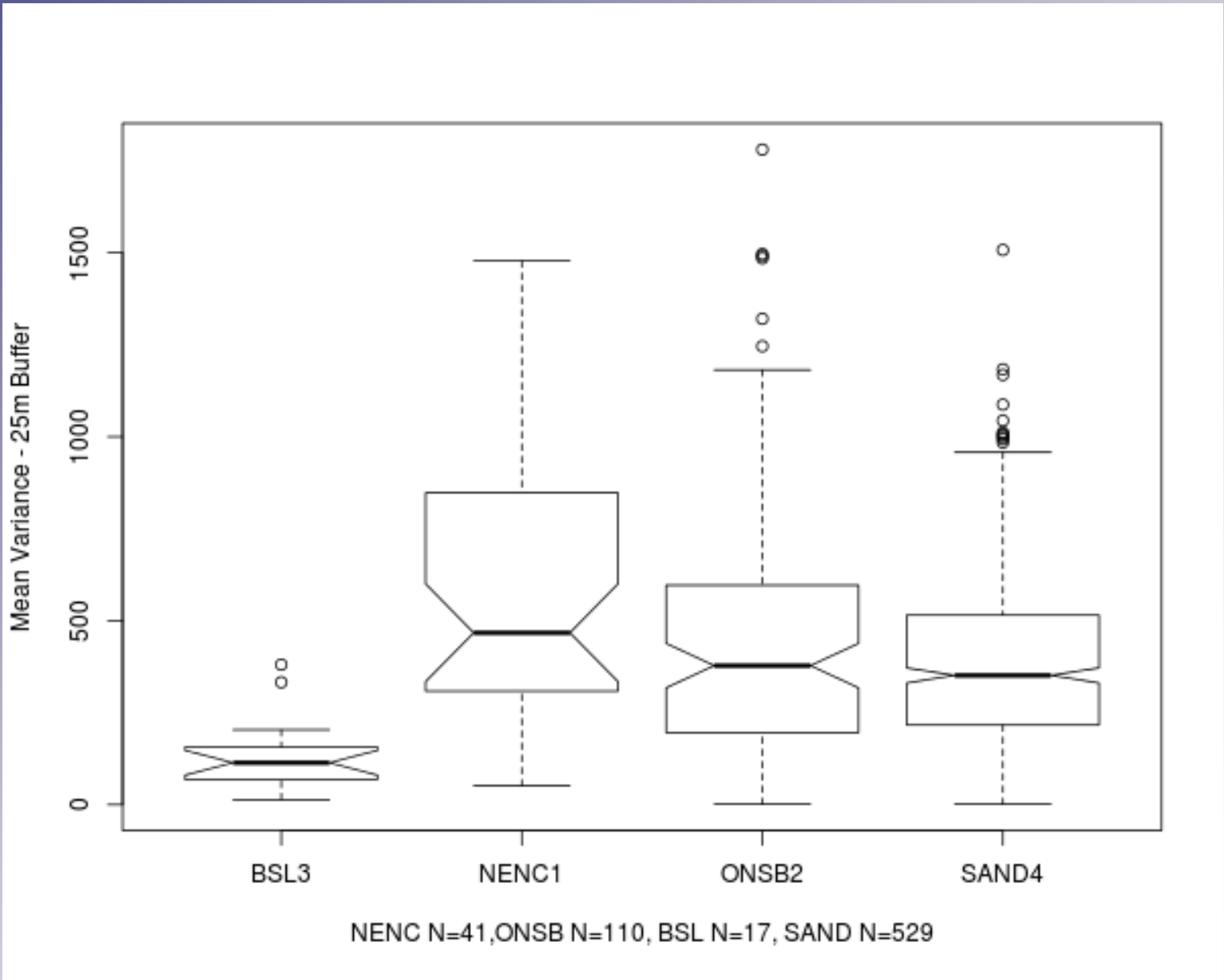
# RCW Canopy Heights in Northeast NC (NENC1), Onslow Bight (ONSB2), SE NC (BSL3), and NC Sandhills (SAND4)



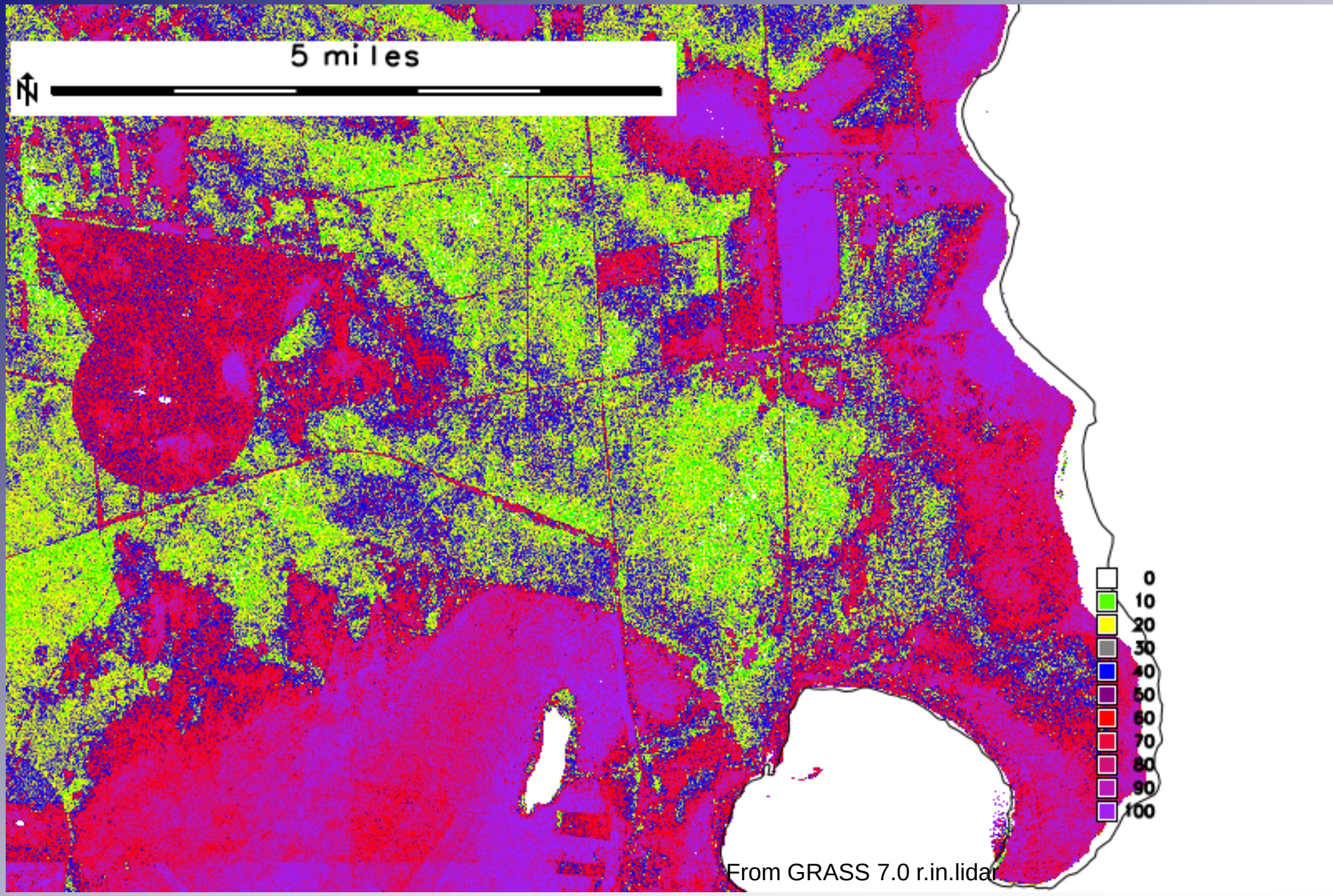
# RCW Skew in Northeast NC (NENC1), Onslow Bight (ONSB2), SE NC (BSL3), and NC Sandhills (SAND4)



# RCW Variance in Northeast NC (NENC1), Onslow Bight (ONSB2), SE NC (BSL3), and NC Sandhills (SAND4)

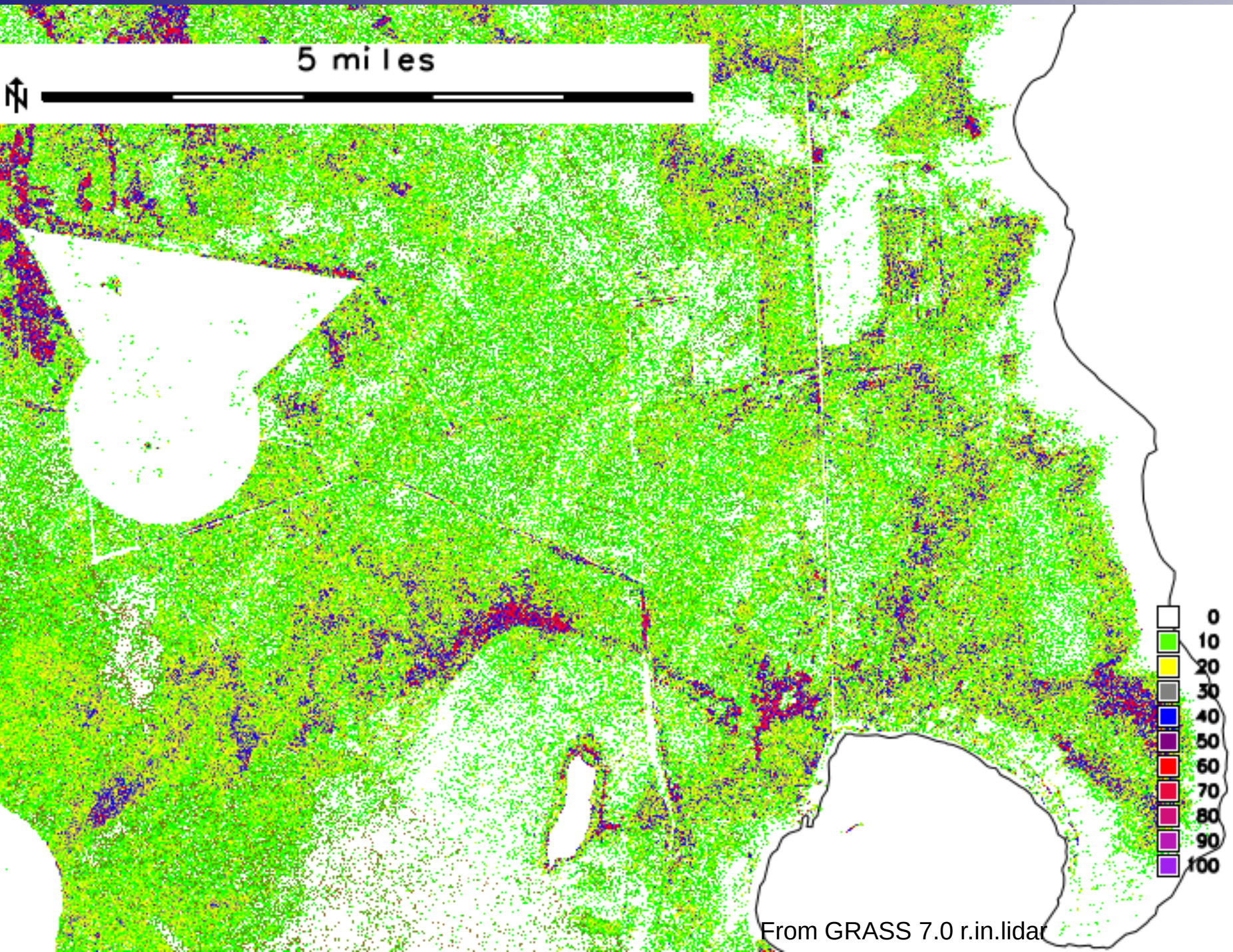


# Percent of the Point Cloud in 0 – 10 ft layer



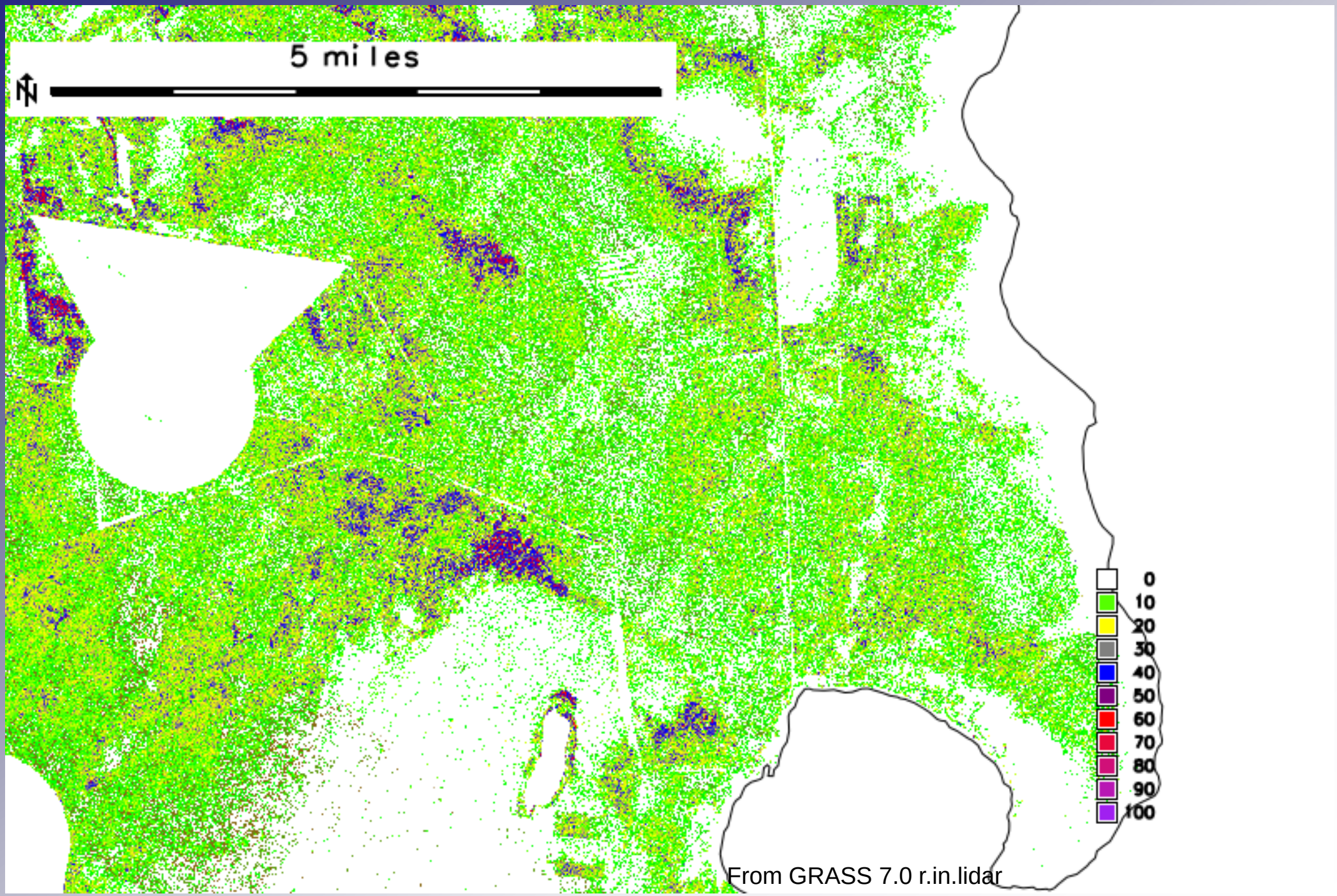

From GRASS 7.0 r.in.lidar

# Percent of the Point Cloud in 10 – 20 ft layer



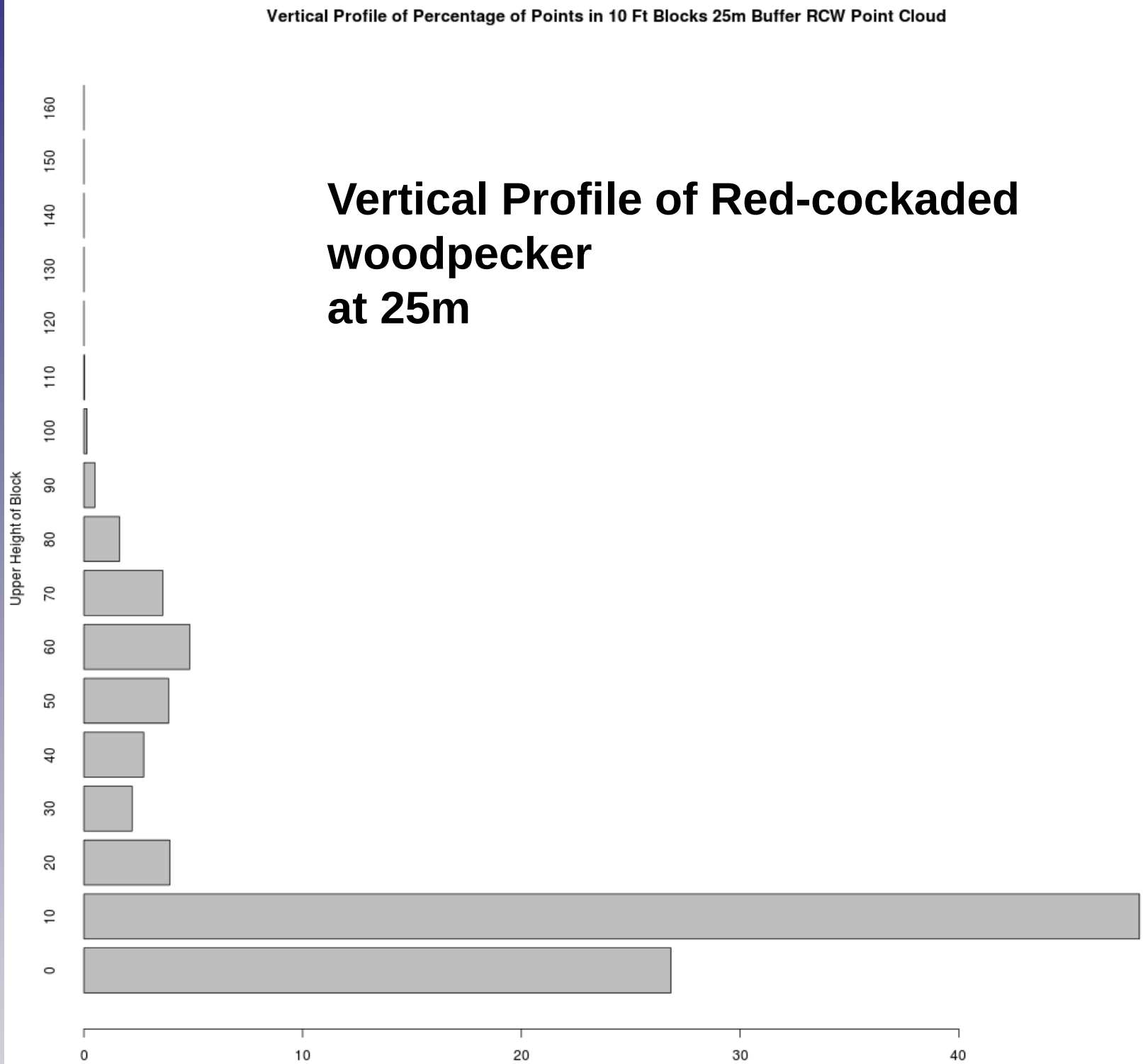

From GRASS 7.0 r.in.lidar

# Percent of the Point Cloud in 20 – 30 ft layer

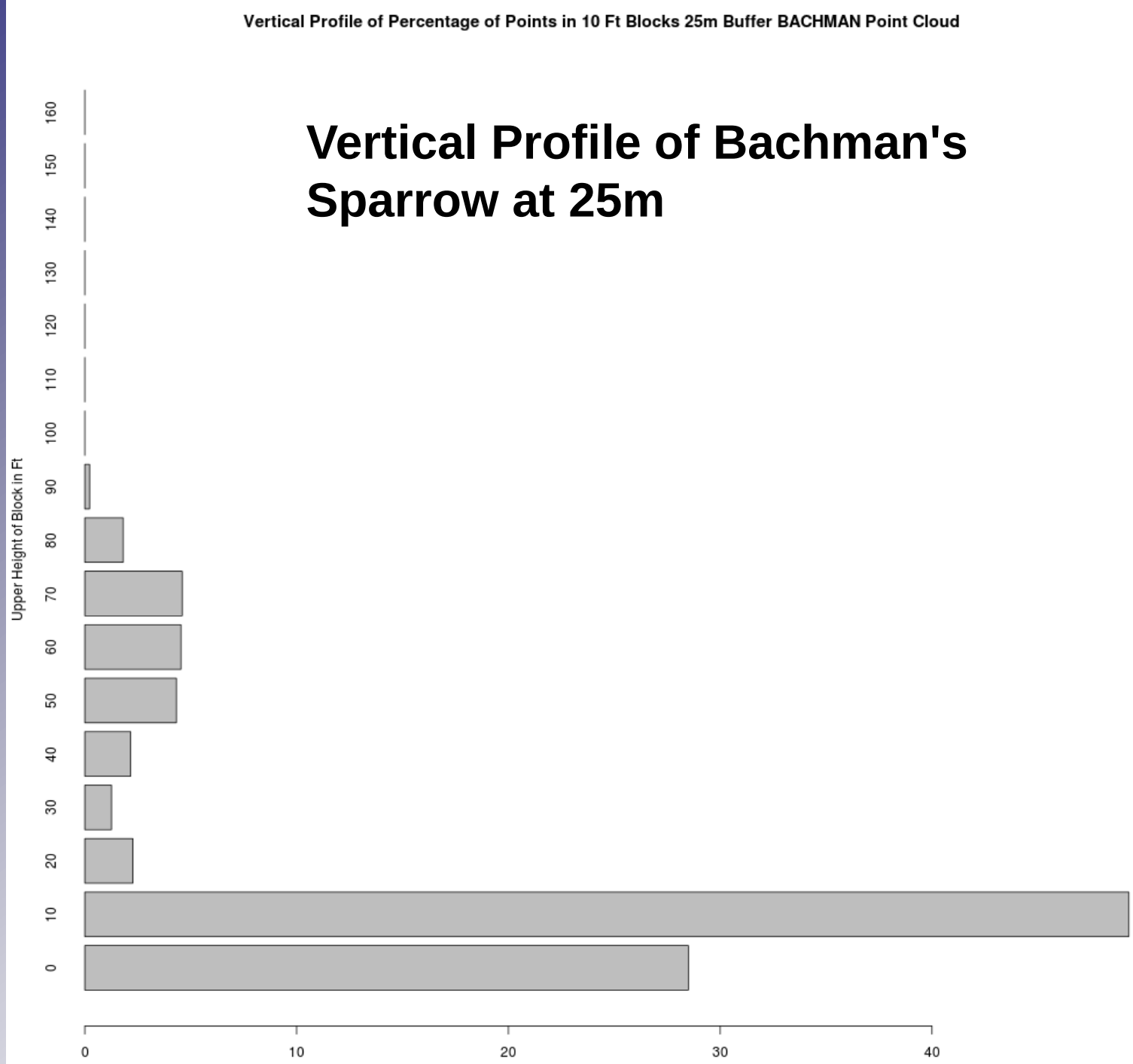
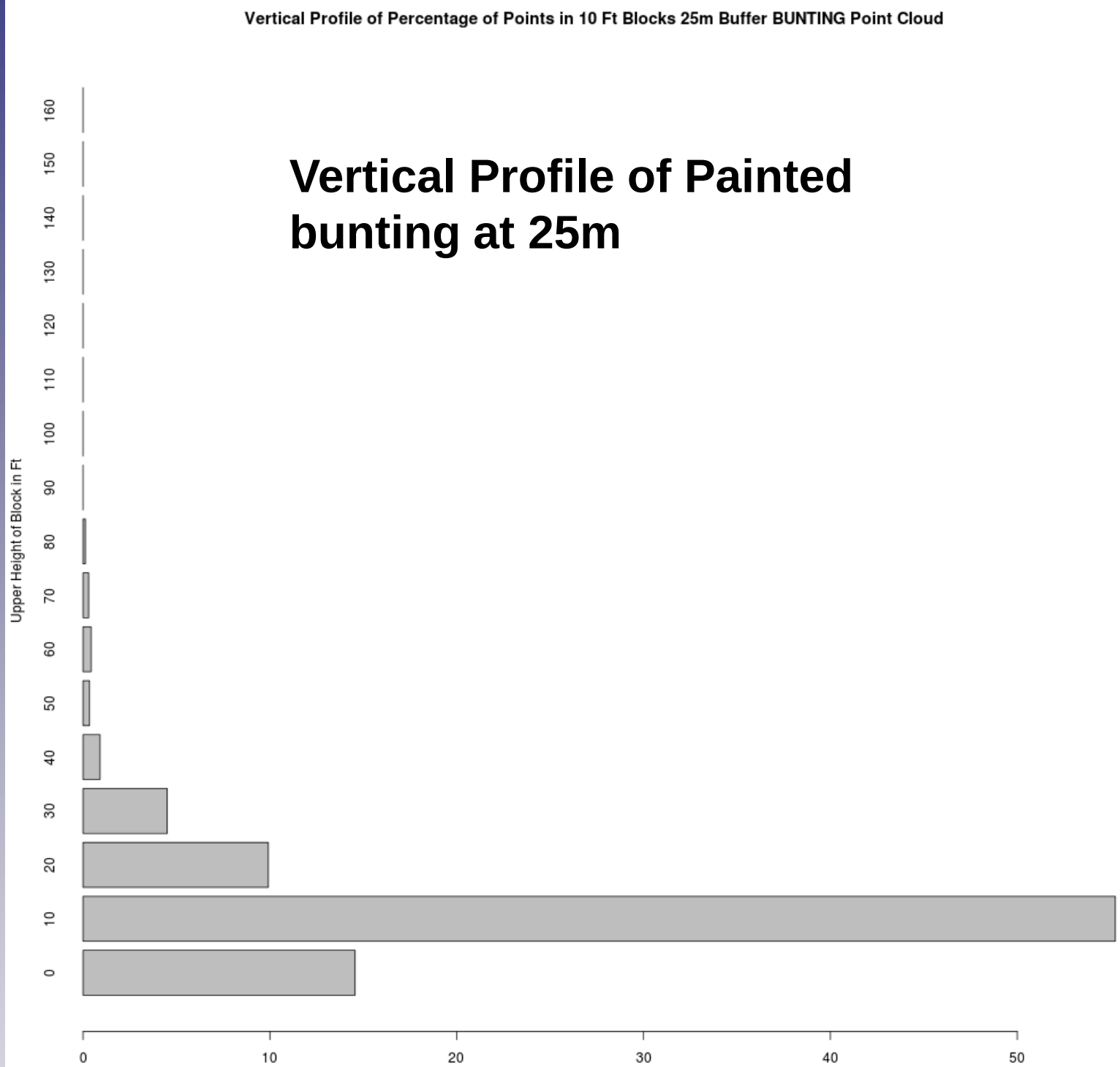



From GRASS 7.0 r.in.lidar

# Vertical Profile of Red-cockaded woodpecker at 25m



# Vertical Profile of Bachman's Sparrow at 25m



# Vertical Profile of Painted bunting at 25m