Meeting Agenda

Operationalizing **Li**dar in Forest Inventory (OLi)

Olympia, Natural Resources Building RM 175a&b

Hosted by WA DNR's Forest Informatics group

January 25, 2016

What	Topic, presenter / moderator	When
Coffee, mingle		8:30 – 9:00
Presentation	Introduction - Jacob Strunk	9:00 – 9:30
Mini Presentations*	DNR (P. Gould), ODF (T. Haren), USFS (L. Rathbun)	9:30 – 10:45
Break		11:00 – 11:20
Mini Presentations*	Tesera (I. Moss), BLM (G. McFadden), MFLNRO (C. Butson)	11:20 – 12:00
Lunch (provided)	Cardboard 3D Lidar Viewer (few minutes)	12:00 – 1:10
Discussion 1	Predict Species with Lidar / hyperspectral – Scott Nowicki	1:10 – 1:40
Discussion 2	Remote Sensing Data Collection – Steve Reutebuch	1:40 – 2:10
Break		2:10 – 2:30
Discussion 3	Tree Lists – Ian Moss	2:30 – 3:00
Discussion 4	Validation example – Dan Couch	3:00 – 3:30
Discussion 5	Plot Database – Bob McGaughey	3:30 – 4:00
Discussion 6	Dealing with Difficult Variables Like Species – Jacob & Peter	4:00 – 4:30
Concluding remarks		4:30 – 4:45
Open Discussion	E.g.: Internal deployment, user integration, inventory derivatives, lidar processing in R or python, component prediction, inventory projections, versioning, updating, change detection, etc.	4:45 – 5:00

*Speakers from these organizations will be introduce their inventories and touch on the following 7 topics: 1) Inventory tool chain 2) What are they inventorying 3) Who are they serving 4) What sorts of outputs are they producing 5) How do they deal with species 6) How do they integrate outputs with an existing inventory system 7) Highest priority for improvements

Summaries of Mini-Talks
OLi Meeting, Olympia WA
Jan 25, 2015

Included summaries:

1) **George McFadden, BLM**
2) **Tod Haren, ODF**
3) **Ian Moss, Tesera**
4) **Chris Butson & Xiaoping Yuan, BC FAIB**
5) **Peter Gould, WA DNR**

George McFadden, BLM

1) Inventory tool chain

    From the raw LiDAR point cloud we create 1/8th acre grid cells where we record LiDAR metrics created by FUSION. We place the grid cells in bins based upon the LiDAR metrics that describe the most variability in the point cloud.

    We measure a series of ground correlation plots randomly selected from the grid cells in each Bin.

2) What are they inventorying

    The ground plots map the trees location of every tree, measure total height, height to crown base, DBH,and species of tree at least 10 feet tall. Anything less than 10 feet is just green stuff close to the ground.

3) Who are they serving

    The information is used by our timber sale planners, wildlife biologists, decision makers and researchers.

4) What sorts of outputs are they producing

    Outputs include total volume, dominant trees per acre, tree heights and variablilty of tree heights. Wildlife information using additional modeling include spotted owl habitat, red tree vole trees and stand structural characteristics including canopy cover

5) How do they deal with species

    With an understanding that there will be error but for planning purposes we can probably live with the error.

6) How do they integrate outputs with an existing system

    Lidar grid cells and other derived layers (DEM, First Return, NHD) are just part of our GIS system and do not require special procedures just for LiDAR. Some of our people have been very imaginative.

7) Highest priority for improvements

    Being able to get updated inventory estimates from base data

    Fine tune inventory estimates with site specific plots

Tod Haren, ODF Inventory Discussion Summary

Inventory tool chain

- FPS database (ver 6.4?) with additional tables and attributes. Loosely coupled to an in house silviculture treatment records database.
- A custom front-end application written, MS Access + VBA, is used by field foresters for maintenance, reporting, etc.
- Custom field data collection apps written with DataPlus
- Stand Level Imputation – Assign similar cruised stand to all non-cruised stands.
  - Manual assignment by forester interpretation on most districts
  - For Tillamook, 250k+ acres, 6000+ stands, a RandomForests imputation was performed using lidar and landsat metrics.
- Landsat processing is handled with Python scripts to perform simple terrain corrections, compute tasseled cap and vegetation indices, band ratios, and PCA.
- Lidar processing:
  - Python scripts to control Fusion tile processing
  - Fusion metrics stored in SQLite databases. Grid metrics, canopy metrics, etc. are concatenated for each 30 meter pixel.
- Python scripts aggregate pixel metrics to stand level.
- Stand level imputation performed with R scripts and package yaImpute.

What is being inventoried?

- Inventory sampling is stand based. Stands have been delineated on dominant vegetation. Originally the inventory was designed for double sampling. Single nearest neighbor imputation now assigns a similar cruised stand to each non-measured stand.
- Each inventory sample point includes a large tree variable radius sample, nested fixed radius plots for small trees, understory vegetation, and snags, as well as a down wood transect.

Who is being served?

- Field foresters - Operational planning
- Stakeholders – Annual reporting
- Board of Forestry, stakeholders, managers – Long-term planning, harvest modeling, growth and yield analysis

What sort of outputs are produced?

- Static reports – Cruise statistics, stand tables, district inventory summaries, etc.
- Dynamic stand condition estimates, harvest prescription analysis, and reporting integrated with GeoPlanner (GIS based operations planning and tracking system).
- Yield tables, projected using FVS, for input into harvest scheduling software, Patchworks.

How are species handled?

- Stand level imputation uses only a single nearest neighbor. The full complement of plot data is imputed.
- Stand level species ratios were include in the imputation model as dependent variables.
- Including landsat metrics became important in the imputation model when species attributes where added.

How are outputs integrated with existing systems?

- Imputation assignments are referenced using foreign keys within the database.
- Individual district databases are merged together into a common SQL Server database.
    - Individual district revisions are keyed to a district ID and a revision ID.
    - System allows query's and views to reference one or more inventory revisions.
- Stand polygon spatial data is stored in the same database.
    - User access is provided as a series of ArcMap layers and query layers.

Highest priority for improvements.

- Stand level imputation is not particularly precise.
- Stand level inventory is likely not capturing the variability within stands to the degree that lidar and landsat metrics do.
- Need working demonstrations of small area estimation and pixel based inventory systems.
    - Comparisons with traditional stand based sampling: cost, precision, bias, etc.
    - Examples of integrating with growth and yield, especially the generation of treelists?

Ian Moss, Tesera

1) Inventory tool chain

This consists primarily of Python plus SQL routines to transform the Ground Plot/LiDAR/CIR/Terrain Indice/ClimateWNA datasets into a form that can be used for analysis. Beyond compiling reference and target datasets, the analyses to date involves a combination of R and Python routines that have been integrated into larger processes to be applied to the reference data in basic model building. These are designed with a small subset of user defined inputs at the front end. The outputs (model parameters) from the reference dataset are then used as the starting point for input into a long series of python routines for purposes of attribution of target data grid cells, summary of these attributes at a "microstand" scale, and with additional aggregation of microstands to larger units based on user defined criteria. Quality control processes have been developed for use throughout to ensure consistent and reliable results and to reduce surprises that are costly to overcome (we have made steady improvements in this area). The speed and reliability of data processing has been expedited by many orders of magnitude through the development of these tools. The tools can be applied by reasonably knowledgeable people who are perhaps less experienced with statistical data analysis techniques and who may not have a strong background in R and Python. The tools are developed in a way that is reasonably fail safe and provide feedback to the user where problems are encountered while at the same time avoiding the tendency to crash under such circumstances. On a personal level I have been continuously driven to up my game in this endeavor and don't see this changing any time soon.

2) What are they inventorying

Land cover (forested, non forested-vegetated, non vegetated), species composition, site index, height, age, crown closure, basal area, quadratic mean tree diameter, gross volume, merch volume (and some custom built attributes related to diameter distributions) and inventory strata assignments. V2. Previous attributes plus tree lists/stand and stock tables, including stand structure classification. V3. Inclusion of untreated stand projections using a growth and yield model, potentially with aggregation of stands into stand types and growth type groups.

3) Who are they serving

Industry operating under license on public lands and public agencies that want access to more detailed, reliable, higher resolution data to better fulfill their mandate.

4) What sorts of outputs are they producing

Used for purposes of land use planning, strategic forest estate planning and harvest scheduling, habitat assessment and protection, road and cutblock layout, and potentially log supply forecasting and cashflow projection.

5) How do they deal with species

Estimating species composition is a standard part of the TESERA inventory attribution process starting at the scale of grid cells. The need for this scale of resolution was identified in early days when it was realized that traditional photo-interpreted inventories were too coarse for reliable species composition estimation. We have undertaken tests to evaluate the quality of our estimates versus those of 3 independent interpreters at the scale of individual plots. We have achieve a 90 % success rate in correct identification of leading species (KHAT = 0.5) compared with an overall agreement between interpreters and ground plots (same dataset) of 72%. Still there are challenges with respect to sampling for those species that are perhaps less frequent within a given landscape and yet still important. These results are obtained based on 4 dominant species (aspen, poplar, pine and spruce) – as the number of species increases the reliability statistics are sure to decrease. Of course much also depends on the data used to explain the species compositions and distributions. Improving estimates of site productivity is also a goal to be fulfilled within the inventory process and so too, related to the species composition question.

6) How do they integrate outputs with an existing system

The inventory process has been developed to as much as possible meet Provincial (ALBERTA, BC) level standards, along with exceeding those standards where additional information is needed to underwrite use of the inventory at both a strategic and operational scales. Routines have been developed to ensure that the data meets provincial level standards both in format and substance of submission. In the Alberta case we have made a submission, been the subject of review, including a joint field review, discussed some issues that we set out to resolve, and have subsequently made some changes followed by a resubmission. In the meantime we have been given approval to proceed with completing the process in an area covering approximately 330 k hectares.

7) Highest priority for improvements

Good question … in search of the holy grail … generating species-x-diameter distributions as a function of the various indices or as a secondary function of whole stand attributes using parametric techniques. Beyond this the development of tools that make these more detailed, higher resolution inventory easy for forest planners to access and use to address operational issues – the amount of data is overwhelming and there is a need to be able to query the data in ways that suggest changes to polygon boundaries and the ability to summarize attributes within those boundaries. In essence the flexibility of these inventories at a high resolution is both an opportunity and a challenge. The last challenge is to integrate the inventories into day-to-day forest operations that includes standard growth and depletion reporting, cash flow projection and reconciliation, etc.

B.C. Forest Analysis and Inventory Branch (FAIB) – Operational LiDAR Discussion in Olympia, WA.

Prepared/presented by Chris Butson & Xiaoping Yuan

Scope: This discussion will cover FAIB's uses of operational LiDAR along with our partners B.C Timber Sales (BCTS) and Licensees who hold operational timber licenses across the province. Over the last 5 years, we have been working with both of these groups for mutual benefit in terms of cost and information sharing with respect to LiDAR information. Our mandate is to; 1) Collect and maintain provincial forest inventories, 2) Monitor the growth and disturbance of stands over time and, 3) Provide analytical support including data collection and strategic analysis for the B.C resource sector.

1) *Inventory tool chain*

   Acquisition> DEM, CHM, Slope, Hillshade>combine with veg layers>stratified sample>plot metrics>predictive models>area-based metrics>generalize/aggregate to forest cover polygons (Enhanced Forest Inventory). Software includes; Lastools, FUSION, global mapper and custom programs and scripts.

   FAIB – We are mainly interested in enhancing our existing forest inventory using the processing chain described above.

   BCTS/Licensee – Mainly interested in raw LiDAR derivatives (i.e. DEM, CHM, Slope, Hillshade, treetops) to guide engineering and harvesting operations.

2) *What are they inventorying*

   FAIB – We are mainly concerned about timber inventory and terrain modelling. What is it? Where is it? How much is there?

   BCTS/Licensee – Field reconnaissance, terrain and karst modelling, harvest and road layouts, mature timber.
   Note – Currently, there is little or no interest in wildlife habitat mapping or ecology.

3) *Who are they serving*

   FAIB/BCTS – As government agencies, we serve public interests however, LiDAR activities tend to be industry driven at this time due to their need of operational high resolution terrain and vegetation information.

   Licensee – Tend to focus on corporate and business needs where LiDAR information can help minimize harvest planning costs and reduce field time.

4) *What sorts of outputs are they producing*

FAIB – Concerned with timber value outputs. We produce inventory rasters to update our existing inventory polygonal information. DEMs are being used to replace our existing 25m provincial DEM information.

BCTS/Licensee – Outputs include: DEM, CHM, Slope, tree tops to get density and quantities of mature timber, stream flow accumulation maps, tactical gridded rasters between 2m-5m resolution that focus on the volume and value of standing timber. Many are now producing multiple resolution inventory datasets including individual tree inventories with volume and species documented for each tree in a high value area.

5) *How do they deal with species*

FAIB – Currently we are only using existing species information from previous photo interpretation information.
BCTS/Licensee – They also use existing species information. With higher point densities becoming more common, they have been using software (Object Raku) to identify species based on crown 3D architecture which leads to the individual tree inventory described in 4 above.

6) *How do they integrate outputs with an existing system*

FAIB – We generalize the LiDAR output rasters to our existing inventory polygons. In previous cases, we've only worked with three main output attributes namely; BA, TPH and P80MAXHEIGHT. These are the fundamental attributes used in our VDYP7 models to generate stand volumes.

BCTS/Licensee – Integrate LiDAR outputs with existing inventory information in a GIS. Also create multi-resolution inventory systems both at the stand level and sub-stand level using LiDAR outputs.

7) *Highest priority for improvements*

FAIB/BCTS/Licensee – Improvements may include: improving spatial inventory, species recognition, integration with our existing inventory system and government storage issues. We are also very interested in the transferability of calibration models as our goal is to somehow reduce the cost/dependence of expensive ground sampling in the calibration process.

Peter Gould , WA DNR

1) Inventory tool chain

Area based analysis: acquire remote sensing, acquire field data, manage the data (fusion, R, postgres Database), model and predict (R, postgres database), generate final products (R, postgres, deployed to Oracle server and retrieved by users from arcmap)

2) What are they inventorying

Typical:

vol, ba, height, tpa, qmd

Less typical:

large tree densities (>20", > 30")

Atypical:

snags > 20", >21", >30"
Dwd
Primary, secondary species, proportion hwd
age

3) Who are they serving

Field personnel, habitat compliance checkers, planners

4) What sorts of outputs are they producing

Rasters (1/10 acre pixel), stand polygons (average of rasters)

5) How do they deal with species

Lidar / naip did poorly -> landsat (landtrendr) derivatives worked well for HW / SW

6) How do they integrate outputs with an existing system

In progress, disruptive at times due to operating at bounds of habitat constraints

7) Highest priority for improvements

Sustainable RS data collection, plot level imputation, strategies for difficult metrics

Registered Attendees

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