

DNR Resource Assessment Program

Forest Inventory Frequently Asked Questions

Contents

Plot Based Inventory (PBI) overview	2
Why Plot Based Inventory (PBI)?.....	2
What is Plot Based Inventory (PBI)?	2
Where is PBI?.....	3
Why PBI instead of USFS Forest Inventory and Analysis (FIA)?.....	3
Are the forest inventory models available everywhere, even in places where a PBI plot was not collected?.....	3
How would someone get involved in PBI?	4
Will PBI data be collected again in the future?	4
What kind of height measurements are collected on a PBI plot?.....	4
Lidar and derived products.....	5
When will new lidar be collected, when will the lidar data be available, and how do I access it?.....	5
What forest inventory products will be available?	5
How can I use the lidar derived products?.....	6
Will there be aerial photography available with the lidar?.....	7
Resources and references	7
Funding sources.....	7
References and manuals	8
Instructional videos	8
Conference presentations and posters by RA staff.....	8
In the media.....	9

Plot Based Inventory (PBI) overview

Why Plot Based Inventory (PBI)?

The Resource Assessment Program (RAP) conducted a pilot project relating field collected, forest inventory information to airborne collected, lidar data. Funded by the Environment and Natural Resources Trust Fund (ENRTF), with collaborators from Cass County, USFS Superior and Chippewa National Forests, University of Minnesota, and Northland Community and Technical College. This study concluded that using area based, fixed radius plots is the most effective method of establishing lidar derived forest inventory models, and for creating an updated stand level forest inventory using small area estimation techniques.

The plot size (1/10th acre circular plots) is a compromise based on considerations of costs of conducting field measurements and the desire to reduce edge effects caused by smaller plot sizes. This larger plot size improved our models by reducing variance, compared to the models produced using data from the smaller 1/24th acre USFS Forest Inventory and Analysis (FIA) subplots. The dense spatial distribution of PBI plots, allows us to estimate forest inventory metrics at the plot scale.

New lidar data has been collected throughout Minnesota thanks to the USGS 3D Elevation Program (3DEP), the efforts of the Minnesota Geospatial Advisory Council's 3D Geomatics Committee and the dozens of local partnerships raising millions of dollars together. RAP is taking advantage of this lidar data collection effort and the result will be a complete, updated, wall-to-wall inventory (all lands and ownerships), for the areas where lidar and PBI are taking place.

Overall, lidar derived forest inventory reduces inventory costs - from currently six to eight dollars per acre to two to three dollars per acre, including plot data collection, processing, and Resource Assessment's investment in lidar data.

What is Plot Based Inventory (PBI)?

PBI is a dense, gridded network of one-tenth acre forest inventory plots (fixed radius = 37.2 feet) distributed statewide across all ownerships in forested conditions. Each PBI plot is approximately 1 mile apart from the next plot, and each effectively represents 1,500 acres in a statewide network.

On mobile devices using Survey123, detailed measurements on all trees ≥ 5 " DBH within the plot area are recorded (DBH, species, status, total/merchantable height). A YouTube video explains and demonstrates the data collection protocol: [Plot Based Inventory \(PBI\) Data Collection Tutorial - YouTube](https://www.youtube.com/watch?v=zcSPPY8XniU) (links to <https://www.youtube.com/watch?v=zcSPPY8XniU>). A detailed procedural manual is also available: [Plot Based Inventory Manual](https://files.dnr.state.mn.us/forestry/pbi-field-manual.pdf) (links to: <https://files.dnr.state.mn.us/forestry/pbi-field-manual.pdf>).

Where is PBI?

The proposed original PBI network of plots were distributed across all forested land in Minnesota, regardless of land ownership. The plots will always be marked as *proposed* until there are official plans to target data collection. Therefore, not every PBI plot on the grid will be visited, because not all forest land ownerships are partners of PBI yet.

Resource Assessment has been expanding PBI involvement with partnerships across Minnesota, now including both Superior and Chippewa National Forests, nine counties, two municipalities, one private industrial landowner, and one Tribal Nation. Efforts are now underway to expand outreach for private forest land involvement. Landowners, businesses, and local governments interested in getting involved in PBI should contact RAP. See the map linked below for a visual of the proposed original PBI plot network.

- Also available to the public on our website: <https://www.dnr.state.mn.us/forestry/resource-assessment.html>

Why PBI instead of USFS Forest Inventory and Analysis (FIA)?

The USFS Forest Inventory and Analysis (FIA) program is a tremendous data resource providing forest inventory estimates at county to statewide scales. However, there are some significant differences between FIA and PBI.

The number and distribution of FIA plots is different than PBI. In general, an FIA plot is representative of about 6,000 acres, in contrast to PBI that has intensity of one plot for every 1,500 acres. The size of an FIA plot is much smaller (1/24 acre) compared to PBI plots (1/10 acre). Larger plots minimize edge effects and provide better correlation between field-based data and lidar grid metrics. The field protocol of PBI requires a high-accuracy GPS plot center point, but FIA does not require strict location precision. In addition, PBI field data is collected within a relatively short window of time from when the lidar is collected (approximately two years), reducing any temporal mismatch (FIA may be up to 5 years of difference since the lidar acquisition).

As a result of these differences, when attempting to use FIA data for both model creation and forest inventory estimates at small geographic scales (e.g., stands or parcels), the data does not support the creation of models within a reasonably acceptable level of variance and model fit statistics. Regardless, FIA data is still highly valuable to the state, holding great importance for several activities including forest management and strategic landscape level planning.

Are the forest inventory models available everywhere, even in places where a PBI plot was not collected?

Yes. Analogous to cruising timber in a forest stand, PBI plots are samples laid out on a grid across the whole state. The forest inventory models are produced across a lidar acquisition area using the PBI plots within that region. The result is wall-to-wall inventory for the areas where both lidar and PBI are taking place. Without the PBI plots collected in a region, the models may not accurately represent the forested conditions of that region. It

is important that as many PBI plots from the proposed grid network are collected to ensure this modeling capability.

Once both PBI and lidar are available for an area, the forest inventory models produced can also be summarized at the stand level. If an area does not yet have stand boundaries, lidar derived information can be valuable to creating those features. A YouTube video explains and demonstrates some basics behind our lidar data processing workflow protocol: [Lidar applications for Plot Based Forest Inventory \(PBI\) at Minnesota DNR - YouTube](https://www.youtube.com/watch?v=-oisFShM6Nw) (links to <https://www.youtube.com/watch?v=-oisFShM6Nw>)

How would someone get involved in PBI?

PBI involvement occurs at different levels depending on role or interest in the forest inventory program. If there is a private landowner interested in getting involved and having a PBI plot collected on their property, there is a different path to getting involved, compared to a consulting forester looking to be a contractor collecting PBI plots, or a partner interested in using data or learning more about the processes involved in creating lidar derived forest inventory data.

Regardless of your affiliation and interest level in PBI the best place to start is the Resource Assessment website or contacting Resource Assessment staff with your questions!

<https://www.dnr.state.mn.us/forestry/resource-assessment.html>

Will PBI data be collected again in the future?

The Division of Forestry may consider several options after the completion of the current round of PBI collection. Some examples include, but are not limited to:

- Acquire new PBI data on a cycle, every 5 years.
- Use growth and yield modeling to track growth throughout the forest, and within stands. Target areas that are not well understood or are experiencing faster rates of change.
- Track harvests and other changes to forest canopy through remote sensing.
- Utilize stereo photogrammetry for height-based models in between lidar collections.
- Integrate FIA with high precision GPS and larger plots sizes to supplement PBI, particularly on other ownerships.

Most likely, a combination of all the inventory activity types and ideas bulleted above will be used to keep our forest stands up to date. Keeping all our forest inventory up to date is an operational change and continues to be a high priority for the Division.

What kind of height measurements are collected on a PBI plot?

Total and merchantable heights are both needed for estimating standing biomass and volume. While lidar can estimate the height of an object very accurately, the length of the merchantable portion of the tree continues to

be an important measurement in the field. Volume equations rely upon DBH and merchantable height, and above ground biomass requires the total height. This, along with the other measurements collected on plot are critical to our modeling efforts. If we were to use only heights from lidar our models would tend to overestimate timber volume.

Lidar and derived products

When will new lidar be collected, when will the lidar data be available, and how do I access it?

Updates and information about lidar data collection can be found on The [Minnesota Lidar Hub](https://lidarhub-minnesota.hub.arcgis.com/) (links to: <https://lidarhub-minnesota.hub.arcgis.com/>). The status of lidar acquisition is shared on a Status Map on the Lidar Hub site. In this map, you can see where lidar has been acquired, where collection is anticipated, and whether the data are available. When lidar data becomes available, it is accessible through The National Map ([TNM Download v2 \(nationalmap.gov\)](https://apps.nationalmap.gov/downloader/) links to: <https://apps.nationalmap.gov/downloader/>).

Lidar grid metrics and lidar derived forest inventory products, on the other hand, will need to be disseminated in a different way. The Minnesota Geospatial Information Office (MnGeo) has been conducting a needs assessment and project definition for a new system to deliver lidar point cloud data and lidar derived products to the public. In addition, RAP is beginning the process of developing a new web application to host lidar derived forest inventory datasets alongside aerial photography resources. For more information about forest inventory products, see below.

The MN Lidar Plan can also be found on the Lidar Hub site. This Plan has been adapted as the partnerships have formed across the various Lidar Acquisition Blocks (LABs). The future of the USGS 3D Elevation Program will involve continued collection of lidar over time, though the specifics of when an area will have new lidar collected is unknown.

What forest inventory products will be available?

Lidar derived forest inventory is a current work in progress and these data are not yet widely available. As processing is completed, certain products will become available as data services on the Minnesota DNR Geospatial Data Resource Site (GDRS) and the Minnesota Geospatial Commons. In addition, RAP is beginning to develop a new web application to host a small list of these forest inventory datasets alongside aerial photography resources.

RAP develops several types of forest inventory products.

- **Canopy height model:** height above ground raster created by subtracting a digital elevation model from a digital surface model.

- **Stand based inventory estimates:** vector dataset of stand level summaries created using whatever polygon or geographic area desired, typically current forest inventory or parcel boundaries. RAP populates the stand polygons with stand-level summaries for a given forest inventory model, as well as provides a 95% confidence interval for the inventory model estimate.
- **20-meter forest inventory models:** raster datasets of the forest inventory model results from plot level PBI data integrated with lidar derived grid metrics and other remote sensed predictors. Models include: max height, basal area weighted height, trees per acre (TPA), stand basal area (BA), gross standing volume, above ground biomass (AGB), above ground carbon, site index (SI), stand age, and quadratic mean diameter (QMD).
- **Lidar grid metrics:** computed (binned) statistical metrics based on the elevation of all lidar returns falling within 1-meter resolution grid cells. RA has produced more than 50 different lidar grid metrics (at 1-m) several of which will be made available to stakeholders via a new web application. The metrics selected for web publication may include: maximum canopy height (canopy height model), average canopy height, 95th percentile of height, percentage canopy cover, standard deviation of lidar return (all) heights, and vertical strata densities (proportion of lidar returns) for horizontal slices from ground to 1.37 m, 1.37 to 5 m and from 5 to 10 m.
- **Stand segmentation:** This is a derived product that groups forest canopy features together into homogenous forest stand segments (biological objects) based on a variety of metrics. This product may look very different from our administrative boundaries, as they represent what is structurally there at the time of the lidar collection, as opposed to reflecting ownership boundaries, stand management history and goals.
- **Other remote sensing products:** Cover-type map produced from multi-temporal, multi-spectral satellite data; tree object segmentation.

Updates will be made to the [RA website](https://www.dnr.state.mn.us/forestry/resource-assessment.html) (links to: <https://www.dnr.state.mn.us/forestry/resource-assessment.html>) as more information about derived product status and access information becomes available.

How can I use the lidar derived products?

Forest inventory data is delivered in both raster and vector format. The stand level polygon summaries can be used in the same way that forest inventory data is currently organized.

The forest inventory raster products provide a wealth of information which can show how variable the forest resources are across and within a stand. The raster-based products can be thought of like a digital photograph, just in terms of a forest metric as opposed to an optical image.

Aside from providing up-to-date stand-level summary data for use in forest management planning, the data provides sub-stand analysis capabilities. Determining the variation of modeled stand attributes within a stand boundary and across a broader landscape will assist staff in field work planning, cut-out analysis, feasibility and re-delineation of boundaries, and cross-boundary collaboration. All the uses may not be immediately obvious, but with time, training, and research, the broader forestry community will fully realize a great return on investment.

The full scope of the uses of lidar derived information is still yet to be discovered, not just by RAP, but the broader forestry community. Keep an eye and ear out for events and workshops sponsored by the Society of American Forestry (SAF) or University of Minnesota Extension, as well as trainings conducted by RAP.

If you need additional training on the use of raster layers, manipulation, and how to work with spatial data within a GIS, RAP is available for longer training sessions, consultation services, and data analyses with a defined project funded through a professional contract or Service Level Agreement (SLA).

Will there be aerial photography available with the lidar?

No, not exactly. Resource Assessment's peak fall color photography program has been on a cycle following the lidar data collection for the last several years. Fall color imagery is available for several overlapping dates in areas with new lidar, but the imagery is not likely from the same calendar year. USDA NAIP photography has been collected every other year for the last several years as well. So, chances are there is a photo available for every forested area only one year apart from the lidar data collection year, if not on the same year.

Resources and references

Funding sources

Environment and Natural Resources Trust Fund (ENRTF), as recommended by the Legislative and Citizen Commission on Minnesota's Resources (LCCMR), 2016-2019:

- Title: Development of Innovative Cost-Saving Methodology for Forest Inventory.
- Summary: The MNDNR's Resource Assessment Program studied using light detection and ranging (LiDAR) technology to innovate how forest inventory is conducted. The study found that using LiDAR can cut costs by as much as 55%, enables the collection of this valuable information across all lands, and makes data available much faster.
- Final report: https://www.lccmr.mn.gov/projects/2016/finals/2016_03o.pdf

Environment and Natural Resources Trust Fund (ENRTF), Legislative Addition, 2022:

- Title: Forest Data Inventory
- Appropriation language: \$500,000 the second year is from the trust fund to the commissioner of natural resources for an enhanced forest inventory on county and private lands. Project due to be completed: 6/30/2025.

References and manuals

Plot Based Inventory Field Manual, go to [Division of Forestry Manuals: Minnesota DNR \(state.mn.us\)](http://intranet.dnr.state.mn.us/forestry/manuals.html) (links to <http://intranet.dnr.state.mn.us/forestry/manuals.html>)

- Also available to the public: <https://files.dnr.state.mn.us/forestry/pbi-field-manual.pdf>

Resource Assessment website: mndnr.gov/resource-assessment

Natural Resources Research Institute (NRRI) Atlas: <https://mnatlas.org/>

Instructional videos

How-To video about PBI data collection: [Plot Based Inventory \(PBI\) Data Collection Tutorial - YouTube](https://www.youtube.com/watch?v=zcSPPY8XniU) (links to: <https://www.youtube.com/watch?v=zcSPPY8XniU>)

Lidar Processing Video: [Lidar applications for Plot Based Forest Inventory \(PBI\) at Minnesota DNR - YouTube](https://www.youtube.com/watch?v=-oisFShM6Nw) (links to: <https://www.youtube.com/watch?v=-oisFShM6Nw>)

Conference presentations and posters by RA staff

2022, MN GIS/LIS Consortium Conference & Workshops, Bemidji, MN. Title: Forest biomass inventories based on integration of strategic plot data with lidar and stereo NAIP imagery in Minnesota.

2021, MN GIS/LIS Consortium Conference & Workshops, virtual (recording posted on their YouTube channel: <https://tinyurl.com/2t2w5uwt>)

2020, Operational Lidar Inventory (OLI) Conference, Olympia, WA. Title: Enhanced forest inventories and new LiDAR plan in Minnesota.

2020, MN SAF Winter Meeting, Brainerd, MN. Title: LiDAR based enhanced forest inventory modeling across three sites in Minnesota.

2019, FIA Stakeholder Science Meeting, Knoxville, TN. Title: Evaluating different resolutions of LiDAR and ground sampling data in spatial forest inventories.

2019, SAF National Convention, Louisville, KY. Session title: How MN DNR Is Using LiDAR to Transform Their Inventory, Presentation Title: Evaluating Spatial Biomass Inventory Models Based on Different Types of LiDAR and Photogrammetric Metrics; Title: Development of Innovative Cost-Saving Methodology for Forest Inventory in Minnesota; and Title: Pre- versus Post-stratification in an Operational LiDAR Inventory

In the media

WCCO Interview [The Quest To Count Every Single Tree In Minnesota Just Got A Lot Easier - CBS Minnesota \(cbsnews.com\)](https://www.cbsnews.com/minnesota/news/minnesota-tree-tracking/) (links to: <https://www.cbsnews.com/minnesota/news/minnesota-tree-tracking/>)

America's Forests with Chuck Leavell – short segment on lidar and forest inventory: [America's Forests with Chuck Leavell Episode 10: America's Forests in Minnesota - YouTube](https://www.youtube.com/watch?v=vOgiu99Qras) (links to: <https://www.youtube.com/watch?v=vOgiu99Qras>)