Analysis of Young Growth Timber Inventory Information and Volume Flow Over Time Reporting on the Tongass National Forest

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Prepared for:

Tongass National Forest and State of Alaska through the Challenge Cost Share Agreement

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EXECUTIVE SUMMARY

Figure 1 demonstrates two log flow for the entire Tongass National Forest (TNF). Results demonstrate that scattered stands begin to hit the 2-log limit in amounts in excess of the projected young growth demand[1] in 2026. Widespread availably of stands reaching the 2-log limit will begin occurring in denser geographic concentrations starting in 2030. Putting together larger Young Growth timber sales inside the next 6-10 years will be challenging.

The analysis detailed in this report **is not a sustained yield analysis**. This volume flow study is simply listing at what point in time each stand will reach what TNF describes as the "two log limit" (where at least half of the volume in the stand comes from trees with at least 2 merchantable logs); the 2 Log Rule.

Figure 1. Two-Log volume and acres contributing over time
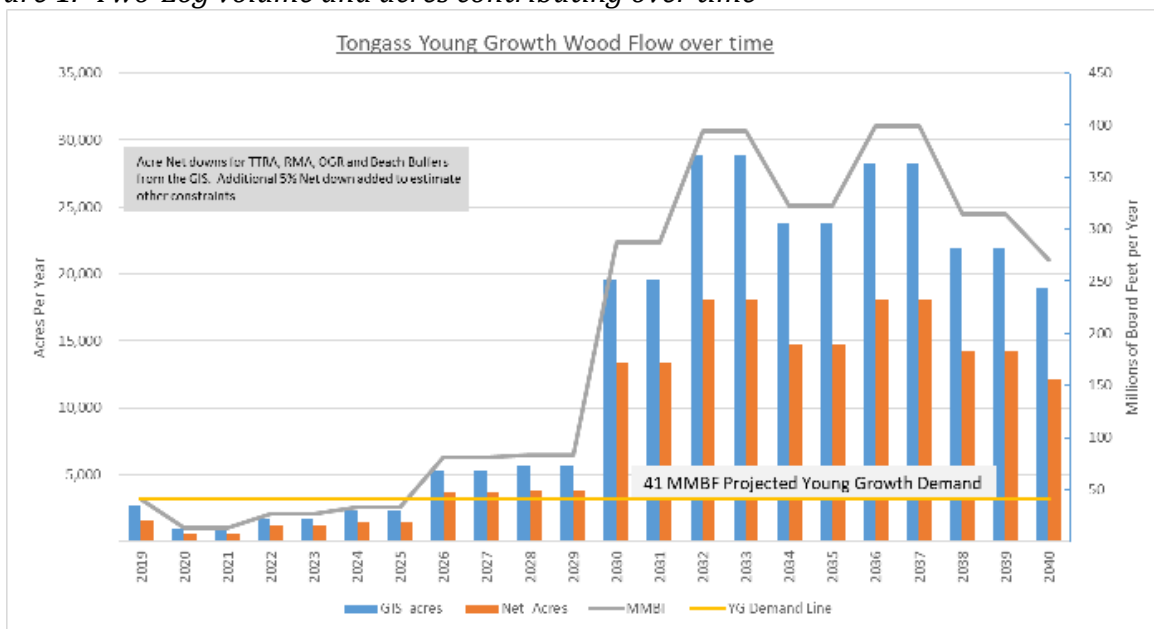
It is critical to note that the summary in Figure 1 does not take into account operational considerations such as proximity of stands to one another and economic feasibility of a small amount of volume in a remote location. Basin by basin analyses need to be performed. To demonstrate this need, a preliminary analysis on the Thorne Bay area suggests that it will need to reach the year 2029 before at least 30 million board feet are available in the same

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[1] Projected Young Growth Demand is taken directly from the 2016 Amendment to the 2008 Tongass Land and Resource Management Plan. This report does not seek to confirm, validate or refute this demand analysis and is presented in this report as a point of reference.

operational area. A key recommendation of this report is for TNF staff to use the time lapse planning tools provided by Terra Verde Inc. to begin operational planning on an area by area basis.

Figure 2. Example of Basin/Area level analysis for timber harvest planning.
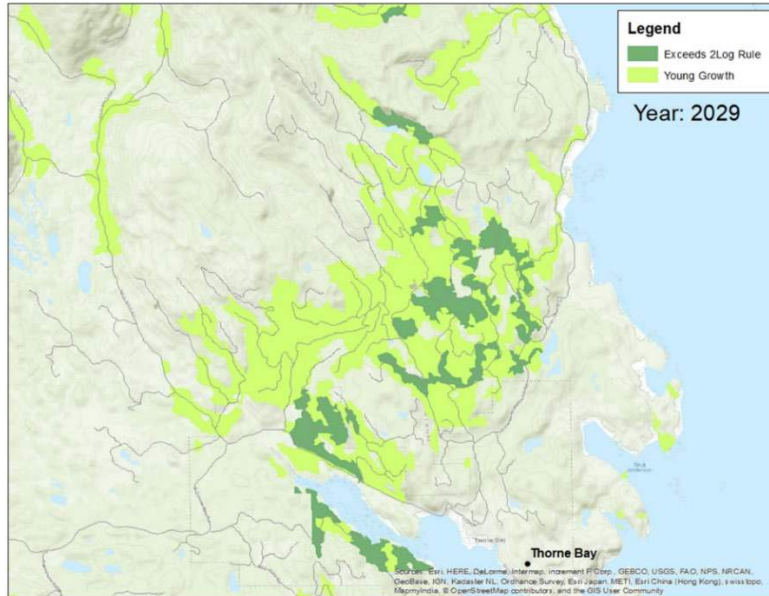
LIST OF DELIVERABLES

- Final Report demonstrating near-term volume flow and detailing analytical methods.
- Fully populated FPS timber inventory database (MS Access format) of Young Growth (YG) Stands with fully revised timber typing and including acre net down estimates for each stand.
- GIS database of Young Growth timber types.
- GIS database demonstrating results from preliminary acre net downs.
- GIS database listing showing in what year each stand reached the two-log limit.
- Time-enabled Young Growth Map and methods for basin-specific analyses.

CORE RECOMMENDATIONS

- Continue refining acreage net downs for resource concerns and operability.
- Reinforce sample by filling in data gaps on the Northern and Central Tongass and in the smaller age classes.
- Identify the top YG harvest opportunity areas with time lapse tool and begin active field recon and sampling.
- Conduct a true Sustained Yield Analysis.

BACKGROUND

The Tongass National Forest (TNF) is undergoing a programmatic shift in its timber management program to move away from the harvest of Old Growth Timber (OG) and toward the exclusive harvest of Young Growth Timber (YG). In order to enable this transition, the TNF is fortifying and improving its information and planning systems to better anticipate the quantity and timing of YG that will be available to support the timber industry.

A key part of improving the base of information was partnering with the State of Alaska through the Good Neighbor Authority and the subsequent development of a Challenge Cost Share Agreement. Through these two mechanisms, a myriad of partnerships and contracting relationships where formed to help expedite the collection, manipulation and reporting of YG timber inventory information. Starting in 2016 the State of Alaska began deploying field crews to put in temporary timber inventory sample plots. The plots where targeted primarily in the Southern Tongass and toward areas containing older and larger trees. By slanting the sample in this way, the hope was to identify near-term YG timber volume that would be able to support the existing timber industry, which is largely located in Southern Southeast Alaska. Over the course of the next three field seasons, State and TNF crews continued to put in sample plots. Upon completion of the field sampling, the USFS compiled all the information and began utilizing and disseminating the information in many ways, including a novel approach of making all the data available through online mapping tools to members of the public.

In 2018 a need was recognized to more fully leverage and utilize the YG inventory information to help inform a timeline for the transition to YG timber management. Terra Verde Inc. was engaged to analyze and manipulate the timber inventory information. The key deliverable was to develop a timeline of when stands would be ready to harvest. TNF staff assembled all GIS and plot information (including thousands of additional plots) to empower Terra Verde's analysis.

In an early 2018 attempt at a two-log analysis, Terra Verde identified a large data quality gap between the plot information and the base mapping information for YG. In short, the plot data's power was being dramatically diminished by shortcomings in the mapping. This is illustrated in Figure 3 where one can see problems with the boundary of the YG unit and that some of the plots actually fell into OG areas due to line work accuracy issues. The recommendation was made to fix the mapping, which resulted in the project expanding to include a comprehensive map adjustment to the entire Tongass YG land-base.

Figure 3. Illustration of Map Accuracy Issues
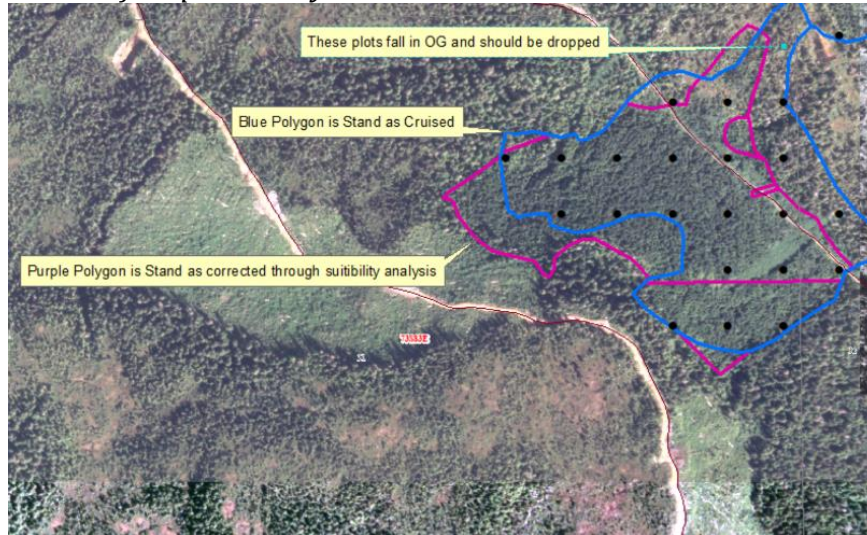
In addition to correcting the boundaries (and thus the acreage) of YG polygons, it was identified that many stands were far too big and had too much structure going on in them. The stand average attributes were washing out all the detail. In Figure 4 one can see a massive stand, full of plots that contains some places with residual overstory, some alder areas and some suitable areas of spruce/hemlock that would drive a workable timber unit in the future.

Figure 4. Demonstrating the need to break up polygons into timber types.
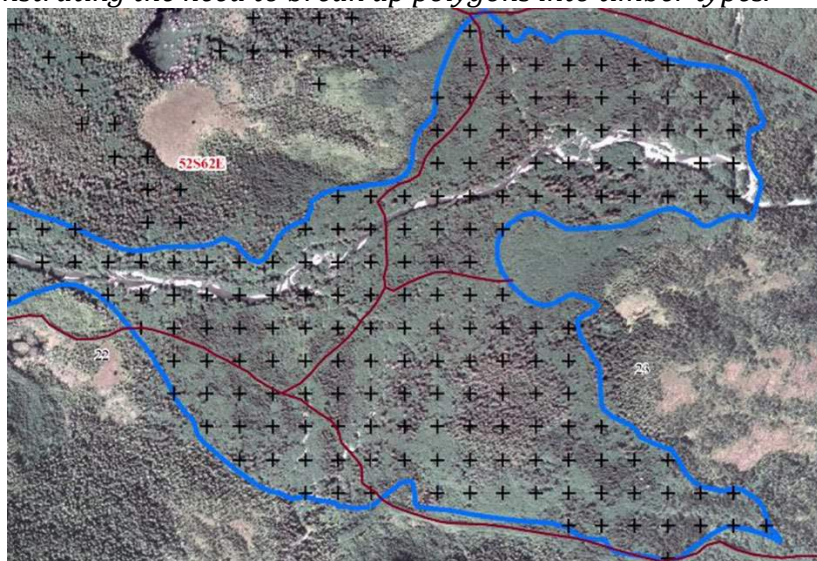
A comprehensive work-flow was developed to bring the mapping up to a higher standard and combine the best available information into a near-term view of YG timber availability.

Figure 5 lists each major step that Terra Verde proposed and ultimately executed in the production of this report.

Figure 5. Work flow for turning Young Growth Inventory Estimates into a Timber Flow Report

Mapping
- Fix the outside boundary of all Young Growth units
- Break up the units into vegetation types
- Assign dominate species using aerial photo interpretation
- Assign size class and stocking level from LIDAR where available
- Where LIDAR not available use photo interpretation

Net Downs
- Analyze the net downs and devise a method to apply net down estimates to the remaining stands
- Adjust estimates of acres available for harvest and management

Inventory
- Post-stratify plots based on new mapping and rebuild inventory
- Each cruised stand gets its own estimate, each non-cruised stand gets a weighted by acres average of all cruised stands with the same label
- Grow each stand using localized site index information

2 Log Report
- Using current and grown estimates of volume, determine in what year each stand reaches the 2 log threshhold for volume
- Incorporate the acre adjustment by stand
- Produce a report and map showing the results

METHODS

The following section details steps and procedures made to accomplish each of the four major workflow components.

Mapping and Timber Typing

Management need

In past inventory and planning efforts, stand information has been summarized based on initial post-harvest stocking surveys and "grown" over time with modeled size-density relationships. But TNF silviculturists have identified that these data are insufficient to represent the array of stand structures arising from complex topography, productivity, and composition in Southeast Alaska. The TNF needed an improved, spatially explicit data product that summarizes stand species composition, height, and horizontal cover to more accurately and precisely assess the scope and variability of young growth timber in Southeast Alaska.

Provided product

The end product is a GIS layer that specifies (1) species composition (i.e., dominant species), (2) tree size (i.e., overstory height), and (3) stocking (i.e., crown closure) in one spatially integrated attribute for young growth timber stands. With consultation from Terra Verde, TNF silviculturists developed the following three-part, four-character attribute codes:

Table 1. Timber Type Key

Position	Explanation	Code	Label	Detail
First 2 characters	Species	RA	Alder Dominant	>75% Alder
		SS	Spruce Dominant	>60% Spruce
		WH	Hemlock Dominant	>75% Hemlock
		CD	Strong Cedar	>40% Red and Yellow Cedar
		HS	Spruce-Hem Mix	SS and WH in other proportions
		CX	Mixed Species	Other combinations
3rd character	Tree Size	4	Large Size	>95 ft height of overstory
		3	Medium Size	70-94 ft height of overstory
		2	Small Size	45-69 ft height of overstory
		1	Saplings	15-44 ft height of overstory
		0	Regen	0-14 ft height of overstory
4th character	Stocking	3	Well Stocked	70-100% Crown Closure
		2	Mostly Stocked	40-69% Crown Closure
		1	Poorly Stocked	10-39% Crown Closure
		0	Non-Forest	<10% Crown Closure

For example, the code SS32 refers to a stand with more than 60% Sitka Spruce, average overstory height between 70 and 94 feet, and average stocking between 40 and 69% crown closure.

IMAGERY AND DATA USED

Terra Verde, Inc. used a combination of aerial and satellite imagery, LiDAR, current forest inventory plots, and past stand survey information from overlaid stand boundary polygons to develop this product.

Past stand survey information

Forest Service stand surveys were used as accessory information to further guide imagery and plot data. These data include the year of forest regeneration, stocking level, dominant species, and volume, as allowed to "grow" over time since regeneration.

Aerial and satellite imagery

Two image databases were used. The first was the USDA Forest Service digital orthophoto catalog of aerial images. Orthophotos were all at least 10 years old and 30cm or 1m resolution. The second was the ESRI ArcGIS World Imagery database, which is a composite of satellite and aerial imagery acquired less than 3 to 5 years from present. The World Imagery database stitches together imagery from various scales and acquisition dates for a seamless, sub-meter resolution product. Data sources include Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. These imagery databases cover essentially the entirety of the subject area, Southeast Alaska.

Forest inventory plots

The forest inventory plots used were those measured by the State of Alaska and the Tongass National Forest via their Challenge Cost Share agreement. These were located on systematic grids throughout a subset of young growth stands on the Tongass. One plot was measured for every 5 acres (plots 469 feet apart). Plots were summarized to display dominant species composition and top height for this analysis. These data are useful for improved typing accuracy and developing analysts' identification skills.

LiDAR

The LiDAR product used was acquired by the State of Alaska and the Tongass National Forest via their Challenge Cost Share agreement. The LiDAR data extends to approximately 40% of the mapped YG. Prior to image cover type analysis, the LiDAR data were processed using FUSION software. Processed products included one GIS layer of overstory height (5 classes), and four layers (with 3 classes each) of crown closure for specified height class. Crown closure height classes did not align perfectly with overstory height classes, so crown closure level was determined in one or two of the crown closure classes that overlapped the stand's overstory height class. The following crown closure height classes were used:

Table 2. Crown Classes

| Crown closure class	Height
4	105-157 ft
3	52-105 ft
2	26-52 ft
1	13-26 ft

For example, if overstory height class was level 2 (45-69 ft), then crown closure class was inspected in both crown closure class 2 (26-52 ft) and class 3 (52-105 ft).

METHODOLOGICAL APPROACH

The following steps were taken to systematically and repeatedly classify forest species composition, height, and cover on the Tongass.

- Navigate to a stand using a GIS.
- Note regeneration year, initial estimate of stocking, species, and volume from the past stand survey information. Regeneration year, especially, can be valuable to develop expected overstory height classes.
- Load aerial and satellite imagery at 1:4,500 scale or coarser, depending on spatial extent of stand. Visually assess stand for significant intra-stand and/or inter-stand patterns. Assess species composition, tree size, and crown closure. As necessary, zoom into stand to further investigate these patterns. If adjacent stands are young growth timber stands that also need typing, consider regeneration year and practicality of current stand boundaries - if valuable, merge stands for improved typing. If appropriate, split stand into smaller units of more homogeneous composition, height, and crown closure (generally greater than or equal to 10 ac. in size), using landscape features to aid splitting whenever possible.
- If data exists, inform imagery-based estimates with CCS inventory plots.
- If data exists, inform imagery-based estimates with LiDAR overstory height classes. Where height classes form relatively homogeneous patches within stand, consider splitting stand.
- If data exists, inform imagery-based estimates with LiDAR overstory crown closure classes. Where classes form relatively homogeneous patches within stand, consider splitting stand. Match crown closure classes to overstory height class.
- Assign four-character cover type label to TV_CoverTypeEdit layer in the New_Lbl field. These steps are summarized in the flowchart, below.

Figure 6. Flowchart outlining the Tongass cover typing process.
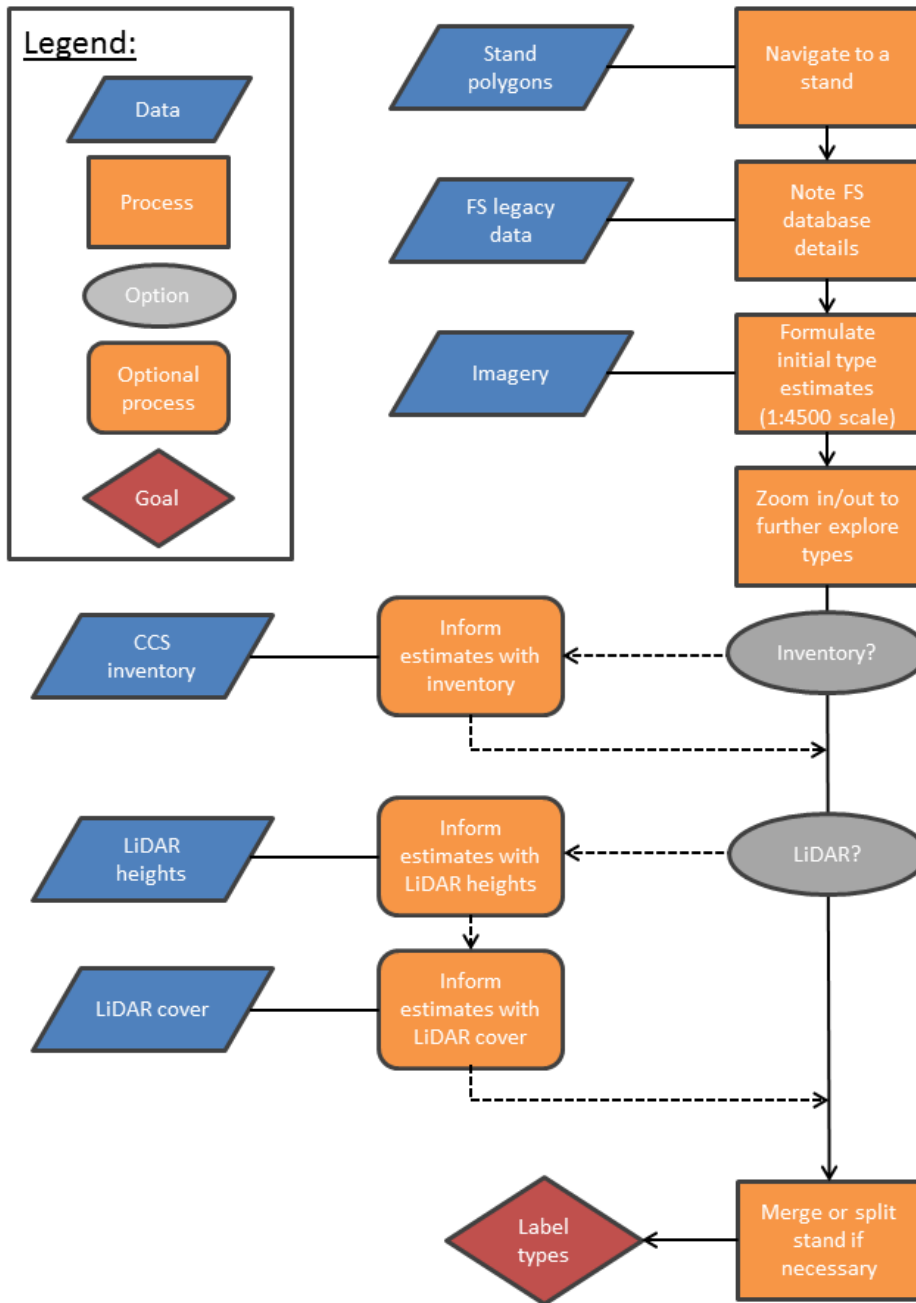
USING LIDAR TO UPDATE HEIGHT AND CROWN CALLS

Early in 2020, when the new Terra Verde generated Timber Type map was being finalized, several new LIDAR data sets were produced and acquired. LIDAR and FUSION generated forest metrics were available for most of Prince of Wales, much of the area around Kake and a significant area around Hoonah. Approximately 40% (209,510 acres) of the YG typed was found also to have LIDAR coverage. Standard procedure during the typing work was for the person performing the typing to make a qualitative call manually using the best available information. LIDAR coverage was extremely helpful for both helping to arrive at a type call and informing decisions about where to insert type break lines.

Once a type call was made for each new stand, Terra Verde used the LIDAR data to calculate a height class and crown class call for all the stands with LIDAR. In this way, the manual, qualitative calls could be compared to a computer generated, quantitative call. A comparison analysis demonstrated that manual calls were very close to computer generated calls with 81% of manual calls matching computer calls and 99.7% of calls being withing one height class of each other. Furthermore, when calls differed by a height class it was frequently because the actual stand height was very close to a class break. Table 3 illustrated the average difference for stands that were one height class different. For example, in the height class 3 column, the manual call was a 3 but the actual (LIDAR calculated) height was 62.7 feet. The "true" height class should have been 2, however the manual call was only 3 feet away from being in the correct class. Given that the two methods were similar, the results validated the manual call technique. The final product contains LIDAR height and crown calls where coverage was available and relies on the original, manual calls in areas with no LIDAR coverage. Over time, if more LIDAR becomes available this method allows TNF to gradually improve the stratification.

Table 3. Manual Ht call vs LIDAR calculated Ht on 995 stands that differed by one class

Height class	1	2	3	4	
Min Ht for class (ft)	14	44	69	94	
Avg height of stands labeled one class too high	12.4	36.0	62.7	89.0	These should be greater than the "min Ht for class" row
Avg height of stands labeled one class too low	17.0	47.7	77.6	98.3	These should be less than the "min Ht for class" row

NET DOWNS

The timber type was designed to completely capture the YG forest lands on the TNF. The final product should be considered a vegetation map, where consistent areas of vegetation are grouped together and given a common label. No consideration was given to other constraints, restrictions or operability of the area for any purpose. How each polygon is impacted by other resource and operability concerns required leveraging other spatial information. For example, a stand close to a major stream might be impacted by buffers to protect fish habitat. Each stand in the YG inventory had to be evaluated for a suite of concerns and the final, operable acreage for each stand needed to be detailed. The following steps document how the area net down analysis was performed. It should be noted that this is the weakest part of the entire two-log analysis. Better information on resource concerns and timber operability is under active development by TNF professionals but is not yet available for the entire YG land-base. Simplifying assumptions were applied and the best forest-wide GIS data was used to make initial net down estimates. The net-down analysis can (and should) be repeated as better spatial information becomes available. The system described here is repeatable and the inventory system as delivered is designed to easily accommodate new net down estimates. Full detail on the process is provided as a template for future updates.

Steps Used for the Net Down Analysis:
1. Road area and areas partially available or unavailable for timber harvest must be netted out of the database and analysis. Start the processing using layers provided by TNF.
2. Create a "Unique ID". This is a new numbering system for YG polygons that is unique but has no direct relationship to other Stand numbering systems in use by the TNF.
3. Create a copy of just the YG stands that only contains a handful of attributes (Unique ID, Stand ID, Veg_LBL and acres)
4. Road Net downs.
   - Start with RoadsWithCoreAttributesRSW from TNF
   - Filter to exclude planned or decommissioned roads
   - Save the layer and add two width fields, one for feet and the other for meters. These are buffer numbers, so they are the width from the road centerline to the ditch (one side of the road).
   - Used the following table to populate road widths

Table 4. Road buffer assumptions

Road Class	Total width(ft)	Buffer (1 side) in attribute table
Double lane/Paved	60	30 ft
Arterial Road/Mainline	40	20 ft
Collector/Secondary	30	15 ft
Local/Spur	20	10 ft
Other or Undesignated	20	10 ft

   - Buffer the roads based on the table above and build a GIS layer called RoadWidths

- Run a GIS union on Units RoadWidths
- Filter for Unique id and Road Code =1, which are the road areas inside YG units
- Calculate acres
- Create a summary by UniqueID adding up the acres RdAcres2.dbf
- 5,636 acres in roads inside YG units is 1.2%. This is a low number but about right based on experience with Tongass management (historically, few roads with large clear cuts).
- Pull RdAcres2.dbf into FPS database and use it to back out acres from the AREA_NET field in the ADMIN table.

5. No-cut area net downs. There are several different no-cut restrictions on the TNF that all need to be considered including, stream buffers, beach buffers, Old growth reserve areas (that sometimes contain YG) and operational constraints of unknown magnitude. At the end of the GIS analysis the net down will be increased by 5% to compensate for operational constraints and currently unmapped net downs.
    - Union Units with OGR, step1.shp
    - Filter for polygon with a UniqueID >0
    - Union Step1.shp with Streambuffers; step2.shp
    - Filter for polygon with a UniqueID >0
    - Union step2.shp with beachbuffers; step3.shp
    - Filter for polygons with UniqueID>0
    - Union step3.shp with RoadWidths to back out road acres
    - Filter for polygons with UniqueID>0 and roadcode=0; this will get rid of all the road corridors and only leave the YG units with all the other constraints cut in
    - Export the filtered layer to AllBuffs.shp
    - Clean up the attribute table of AllBuffs by deleting fields that won't be used
    - In the AllBuff layer, recalculate acres for all the stand
    - Add a Field called Ac_factor which will hold the acre adjustment factor
    - Add a field called Adj_Acres that will contain the adjusted acres.
    - Filter AllBuff for just the buffer areas. Do this by selecting all polygons that are flagged to be part of OGR, RMA or BeachBuf.
    - Export the layer to BufFinal.shp
    - Set the adjustment factor to 1 for everything except the Buff1000ft=Y. Half of the acres in these beach buffer areas are available for harvest. For these polygons, set the adjustment factor to 50%.
    - Multiply GISAcres by ac_factor to get the Adj_acres (or adjusted acres)
    - 127,684 acres in restrictions (30% overall). Unit by unit analysis on operability suggests this number is commonly between 40-50 percent after refined on the ground considerations. **An additional 5% reduction will be applied for the time being (35% total).** Younger stands that were included in recent mapping are not as heavily impacted by acre net downs.
    - Polygons acres are summarized by Uniq_id and a table called Ac_RPT.dbf is created and imported into the FPS database

INVENTORY

Construction of a new timber inventory database was necessary to complete growth projection and the two-log analysis. Since the mapping effort created entirely new mapping that did not match the original cruise design, accommodations had to be made. Plots were re-stratified and aggregated into new stands before being compiled. When combined, some plots had incompatible design and had to be screened out. The re-stratification of plots also created the problem that some new stands only encompassed a handful of plots. In order maintain the ability to calculate quality statistics, plots were removed from any stand with less than 3 plots. Once plots were re-assigned and compiled, strata level averages were calculated and estimates were populated into stands that were not sampled. All stands (both sampled and unsampled) were assigned their own site index value to allow each stand to be grown according to its own innate growth potential. All stands were grown forward for 100 years in 2-year increments. Overall construction of the inventory database was a detail-oriented process with many components. The primary steps and assumptions are listed here:

Steps Used for construction of new YG inventory database:

1. Separated all Young Growth stands YG = Y into a separate GIS database and established a Unique ID for each polygon/stand. Layer is called "YG_retype".
2. Updated Site Index for each stand
    - Created a subset of the site index layer for the YG lands only.
    - Spatially join site index subset to YG_type so that each point was assigned the UniqueID of the stand it falls inside.
    - Set aside the layer for later link to FPS admin table.
    - Calculated the average SI value (88) for use in any stands that a sample did not fall inside.
3. Plot Re-stratification
    - Combined CCS plots (TNFYGInventoryPlots) and Stand exam plots (YG_StandExam) into one layer with a Union operation.
    - Re-number the plots
    - Assigned a NEW, unique plot number to every plot in the Plot GIS layer. This prevented problems if (for example) two different plots numbered 1 fell inside a newly created stand.
    - Created a new FPS database and linked the plots file from the GIS "Plots_Uniq_ID". This GIS attribute table contains one record for every plot. It has the old stand id, new stand id, original plot number and new unique plot number.
    - From original database from TNF staff (FPS_KruzerYG) imported the CRUISE and PLOTS table and store as a record inside the new FPS database.
    - In the table PLOTS_KRZ_crosswalk created two new fields to hold the new stand and plot number, this allowed reaggregation of the plots into new stands while maintaining a record of where they came from.
    - Update the New stand and plot number fields in the table containing the cruise data

- 1,285 plots were dropped because they fell into old growth, were deemed unreachable or otherwise dropped in the field or in the office.

4. Built the CRUISE table for the reconstructed stands and checked for multiple basal area factors.
   - 26 stands found were this is a problem (2 BAFs inside a Uniq ID)
   - 110 plots were dropped due to incompatible designs. (713 trees)
   - Look for stands with plots cruised in two different years.

5. 31 stands had year conflicts. Plots cruised in different years fell into the new stand.
   - If age gap was more than 2 year, some of the plots were dropped. 46 plots were dropped due to large age gaps. 480 trees involved

6. Took a look at the number of plots per new stand. Drop plots from stands with only 1 or 2 plots.

7. Built FPS ADMIN table.
   - Appended all the relevant records into the ADMIN table. This includes stand id, veg_lbl, region, GIS acres and birth year.
   - Imported the site index value for each flagged stand. First link the site index point grid and then built a summary table based on UniqueID. The query calculates the average site index and site shape for each UniqueID. 11,823 stands are updated. 565, most small, stands had no site. The average value of 88 is used in these cases.

8. Built FPS CRUISE table.
   - For only the plots being used moving forward, summarize the plots by stand. Carry BAF, cruiser and year.
   - Assign all plots to December 1st of the adjusted measurement year.

9. Built FPS PLOTS table.
   - Use the table called Plots_Uniq_ID which contains all the tree level records. Appended all the records into PLOTS but use UNIQID as the stand ID and UniqePlot as the plot number. Only import where UsePlot is "Y". 118,277 tree level records are imported.

10. Ran the cruise compiler on the new stands,

11. Grew all the cruise stand forward to 2019

12. Cruise Expansion

Table 5. Cruised vs Expanded Stands

	Tally	GIS Area
No-cruise	11,176	397,343.85
Cruised Stands	1,212	69,126.67

- All the 01 and 11 strata have very light samples, only 19 plots. As a non-designed sample that covers 84,000 acres, these 19 plots were discarded instead of using them. They were replaced with the following stocking estimates:

Table 6. Stocking Assumptions for 01 and 11 Strata (all species labels)

	SPECIES	TREES	DBH	HEIGHT
	Stocking Assumptions			
01 North	SS	1,123.00	0.00	5.00
01 North	WH	3,037.00	0.00	5.00
01 South	SS	966.00	0.00	5.00
01 South	WH	3,191.00	0.00	5.00
01 South	RC	270.00	0.00	5.00
01 South	YC	67.00	0.00	5.00
11 North	SS	140.00	3.00	20.00
11 North	WH	210.00	3.00	20.00
11 South	SS	120.00	3.00	20.00
11 South	WH	200.00	3.00	20.00
11 South	RC	20.00	3.00	20.00
11 South	YC	10.00	3.00	20.00

- For 01 strata set up a "PCT1" regime that things the stands down to 350 trees per acre when the Crown Competition factor hits 250.
- Created a table called "A_StrataGrouping" This table contains an explanation of how strata were collapsed when a sample was not present or was too weak to stand on its own.
- Assign the GRP_LBL to the ADMIN table so it can be used for expansion

13. Looked at Expansions to see if there is enough power to perform expansions by area. Statistics are presented at 1 Standard Deviation.

- Tract 1 : ABC Island and Yakutat. 5% sample by acres overall on its own.

Tract 1						
NumPlots	**NumStds**	**SumArea**	**TpaErr**	**BAErr**	**CubErr**	**BrdErr**
1,290	106	6,185	5.35	1.73	2.10	3.01

- Tract 2: Kupreanof, Kuiu and Zarembo. 10% sample by acres overall on its own.

14. Tract 2						
NumPlots	**NumStds**	**SumArea**	**TpaErr**	**BAErr**	**CubErr**	**BrdErr**
2,190	242	13,004	2.67	1.17	1.38	2.34

- Tract 3: POW, Cleveland and everything south. 17% sample by acres overall on its own.

Tract 3						
NumPlots	**NumStds**	**SumArea**	**TpaErr**	**BAErr**	**CubErr**	**BrdErr**
10,919	836	48,342	1.81	0.53	0.65	1.08

- Tract 1 and 2 combined 7% sample by acres overall.

Tract 1 and 2						
NumPlots	**NumStds**	**SumArea**	**TpaErr**	**BAErr**	**CubErr**	**BrdErr**
3,480	348	19,190	2.46	0.97	1.16	1.85

- All Tracts Combined 12% sample overall

All Tracts						
NumPlots	**NumStds**	**SumArea**	**TpaErr**	**BAErr**	**CubErr**	**BrdErr**
14,399	1,184	67,532	1.46	0.47	0.57	0.93

- Result of this analysis was to separate the Tongass into two areas, North&Central and South. Tracts 1 and 2 will be combined and Tract 3 will stand on its own.
- For Tract 1 and 2 the following strata were left with "forest-wide" estimates due to a light sample: CD22, HS21, HS43, WH13, WH33
- For Tract 3 (South Tongass) the following strata were left with "forest-wide" estimates due to a light sample: CX12, CX42, HS21, HS22, HS32, RA22, SS32

TWO LOG REPORT

Once the inventory database was built and acres adjusted, the final steps were to make growth projections for each stand in the inventory and identify in which year the trees in each stand grew tall enough to exceed the 2 Log Rule. The results were built into the GIS database and summarized by year. These final steps are:

1. An analysis was run on the DIBCLS table (log stock table) for sampled stands enforcing a strict interpretation of the 2 Log Rule, "Half the volume in stands must come from trees with at least 2 logs". There were some unexpected results. For example, an alder dominated stand that had only two large spruce trees actually passed the rule because the only two merchantable trees in the whole stand had two logs. The stand was clearly not operable. Using all the cruised stands as evidence a simplified rule was produced that is superior in terms of operability. Stands that had a top height of $\geq$ 90 feet and contain more than 20,500 board feet were determined to both pass the strict interpretation of the 2 log rule and also have a chance at containing an operable amount of volume per acre.
2. Grow out all the stands in the inventory for 100 years in 2 year increments. Stands were given one of the two Regimes listed below.

REGIME	PctHt	PctSur	TRT_Key	TRT_Val	THIN_METH	THIN_MV	THIN_LVL	THIN_LVLV
GROW	68%	40%	1	1	0	0	0	0
PCT1	45%	35%	2	250	4	99	1	350

3. Wrote a series of Queries that picked out when each stand exceeds the 2 log rule limits.
    - #2LogMaturity_step1 – Filter the Stand table for the records that exceed the 2 log rule. Every year after the stand hits the 2 log rule will also show up.
    - #2LogMaturity_step2 – This query finds the first year (lowest year number per stand) when each stand hits the rule
    - #2LogMaturity_step3 – Links the first 2 log year record back to the stand table in order to determine the volume and top height in the year when the 2 log rule was hit. This is the "master" list of when each stand hits the 2 log rule. There are 11,639 Stands in this list which means that 743 stands never hit the 2 log rule limit (even given 100 years). No research was

done on these stands but it could be due to high hardwood components or very low site index values. This query is used to create a permanent table called "A_Yearof2LogbyStand".

- In the Young Growth timber type layer "YG_Retype" a column was added called "TwoLogYR". This column was populated with the first year that this stand would hit the 2 log rule when allowed free to grow given the assumptions in the FPS model for stocking and site. This attribute can be used to build theme maps.
- In my map display I have a copy of the YG_retype layer that I enable time for and filter out the zero year stands. This layer is called 2Log_ready and is on top of the YG_retype layer.
- Use the Arc GIS time conversion tool to calculate a date field from the year integer, call this field YrDate
- Enable time in the layer with in the layer properties, be sure to click "display time cumulatively"
- Instructions for utilizing the time series functionality is included in Appendix 1.

RESULTS

MAPPING

Timber Typing efforts greatly refined the estimates of YG currently on the Tongass. In general, this work increased the estimate of YG acres. The new mapping shows approximately 466,000 total acres.

Table 7. Acres by Vegetation Label.

VEG_LBL	GIS Acres	Net Acres	VEG_LBL	GIS Acres	Net Acres
CD13	2,217	1,670	HS32	2,660	1,109
CD22	727	459	HS33	36,490	21,335
CD23	1,528	1,155	HS43	2,474	1,539
CD33	426	250	RA22	607	211
CX01	55,919	45,813	RA23	10,465	3,645
CX11	28,383	21,612	RA32	222	18
CX12	56,628	43,234	RA33	7,218	3,118
CX13	29,536	20,957	SS23	11,711	7,165
CX22	25,454	16,613	SS32	1,745	975
CX23	44,444	27,780	SS33	9,924	5,915
CX32	2,521	1,300	SS43	853	301
CX33	20,553	10,770	WH13	2,564	2,032
CX42	1,496	817	WH23	1,610	1,071
CX43	1,963	1,149	WH33	693	512
HS13	31,135	23,680	**Totals**	**465,914**	**316,732**
HS21	3,382	1,998			
HS22	10,228	6,098			
HS23	60,138	42,434			

INVENTORY

The true result of this analysis is a comprehensive map of every Young Growth stand on the Tongass National Forest with a label indicating in what year it is estimated to meet or exceed the 2 Log Rule. This information is best displayed using maps such as Figure 2 or the GIS procedures that are detailed in Appendix 1. For purposes of gaining a general understanding of the timing of YG maturity and harvestability, Figures 7 and 8 demonstrate when Young Growth volume becomes available in abundance. Before 2026 only scattered stands that were the product of early logging or on very high sites start to exceed the 2-log limit. Kosciusko Island contains the largest cluster of merchantable YG stands available today in 2020. At the time of this report being written the TNF is already operating an active timber sale on those acres. Other areas of abundant YG gradually come online after 2026 with widespread opportunity starting to come up after the year 2030.

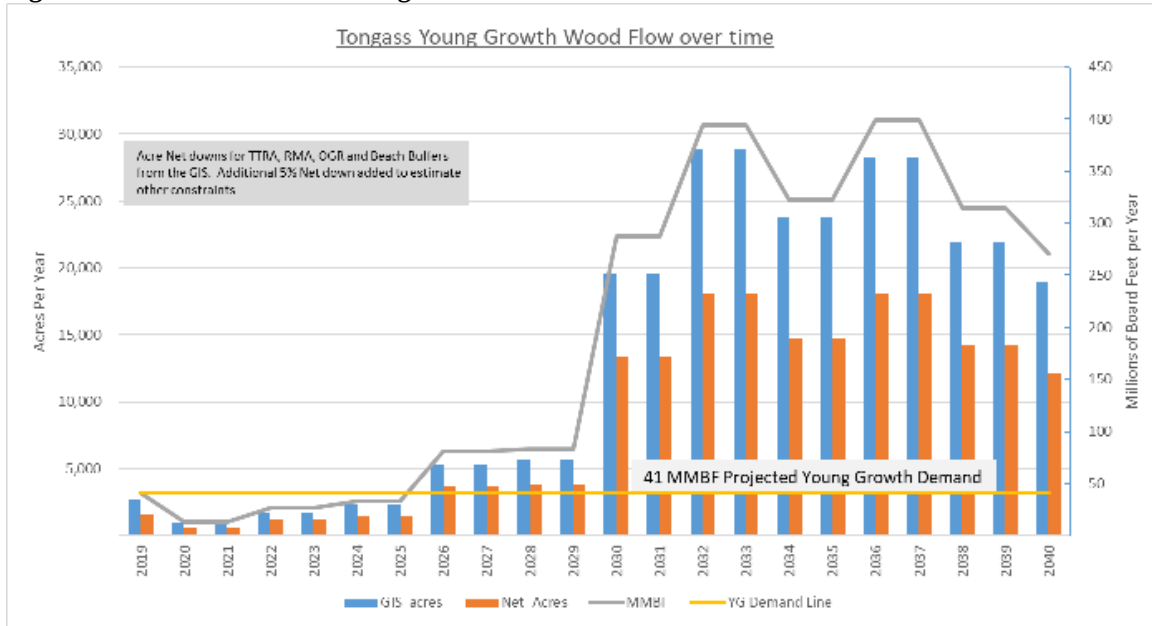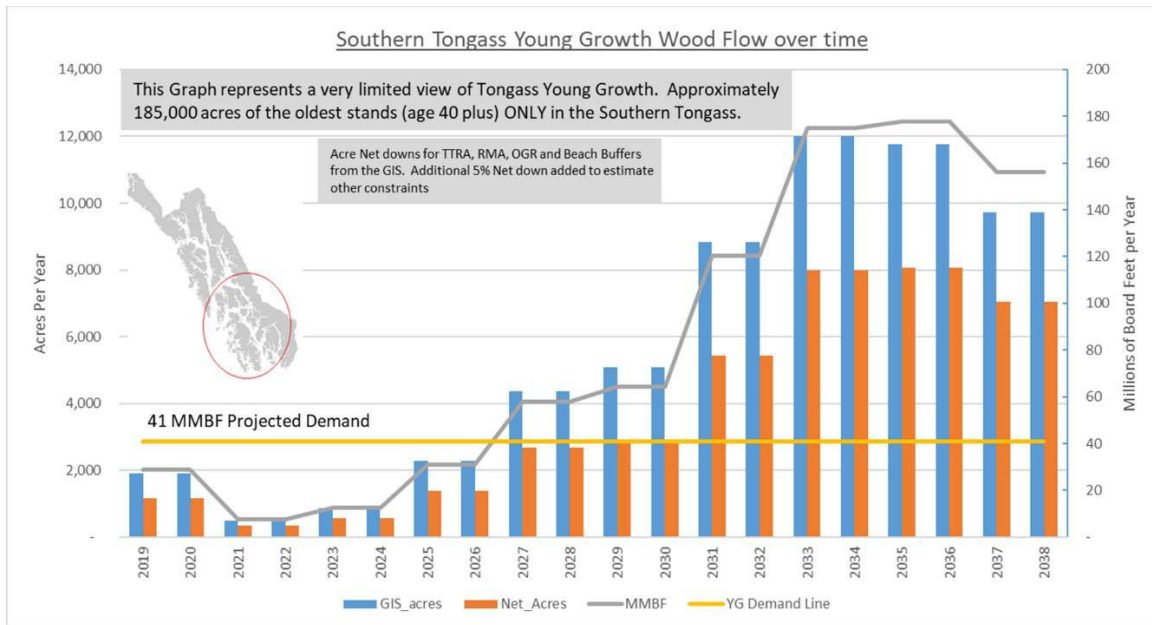*Figure 7. Forest-wide Two Log Volume over time*

Figure 8. Two Log Volume for only the oldest stands in the Southern Southeast

DISCUSSION AND RECOMMENDATIONS

STRENGTHS AND WEAKNESSES OF THE CURRENT SAMPLE

- Plots on Prince of Wales and in the Southern Southeast do an adequate job describing the oldest and largest of the YG stands in that area.
- The current sample has been bolstered through the use of recent LIDAR data.
- The Northern Southeast sample is very weak and cannot be reliably used for planning. Because species mix is so different north of Prince of Wales (where the sample is concentrated) it is not advisable to use POW sample plot data to generate estimates on the northern TNF. If timber sale planning on Northern Ranger Districts is a goal, there will need to be additional sample plots installed.
- Ideally, there would be an adequate sample to also break out the central Tongass. The current sample is much too weak to support this.
- There is very little data in the years immediately following logging. This is not a critical age class but a small amount of data acquisition by geographical area would improve the database significantly.
- Post thinning sampling (stands between 15 and 30 feet tall) is completely missing. Attempts were made to import data from PCT contract compliance inspections without success. However, there is a significant opportunity to collect PCT contract inspection data that would also feed into the inventory system. This work flow should be evaluated.

AREA NET DOWNS, THE GREATEST GAP IN EXISTING INFORMATION

- Sufficient work has been done both inside the analysis contained in this report and work completed by TNF staff to suggest the net down of YG acres is between 20%-60% with an average net down of 30%-40%. That is an immense reduction between the YG acres on the landscape and those available for future management and timber harvest. The actual acres available for management will have a far greater impact on volume available for harvest than any of the inventory information or assumptions that went into this report. The highest priority for future YG timber management must be to accurately define the scale of this net down and prevent any additional loss of acreage due to unnecessary area restrictions, including partial harvest restrictions. At 317,000 acres of unrestricted YG available the TNF is not left with a very large land base to support a viable timber industry. Every acre of this sliver of the Tongass must be maximized if timber management is to remain among the management goals supported in the forest plan.

- LIDAR should be used to update stream mapping, fish stream buffers. In addition, this technology can be used to help predict areas of highly vulnerable karst. To the greatest extent possible, robust, remote technologies should be utilized to predict and protect resource concerns before field crews even begin to conduct timber layout. Early and stable estimates of harvest restricted areas will help in the early stages of timber unit planning and avoid unpredicted fall down in volume offered.

NEXT STEPS WITH ANALYSIS TO BETTER INFORM DECISION MAKERS

- A missing competent in the understanding of Tongass YG is a true sustained yield analysis. Inventory information should be combined with the acre net down restriction to make this happen. The database provided through this work is already set up for such an analysis with very little additional effort. A sustained yield planning process will mitigate the risk of over or under harvesting in any given year and will help avoid gaps in timber supply over time.
- GIS technologies can be used to conduct robust space-time analyses. Procedures should be built to answer overarching questions about the quality and timing of the YG timber supply. With the base information delivered, Tongass staff can (for example) identify areas that will provide 30 million board feet of available timber on the same road system or attached to the same Log Transfer Facility. A ranked list of opportunity areas should be built and field reconnaissance effort deployed to these areas.

APPENDIX 1: USING THE TIME-ENABLED 2-LOG MAP TO VIEW VOLUME FLOW BY GEOGRAPHICAL AREA

This following procedure will guide the user through the steps necessary to set up a time lapse map that shows when each stand in the map's view hits the "2-log" limit as an indication of when it is ready for harvest. This tutorial is written for ArcGIS 10.x but the same analysis is possible in ArcPro and with other common GIS software packages

1. Open ArcGIS and set up a Map Document with relevant base layers, such as roads, imagery, shoreline and streams.
2. Add the Layer called "2Log_ready.lyr" which was delivered by Terra Verde Inc as part of the final "2-log" deliverables. This layer file points to the GIS dataset "YG_retype" which was also included in the deliverables. It is recommended that the user add the source dataset in addition to the time enabled layer. By placing the time enabled file on top of the source layer and making each a different color, one will be able to see changes over time.
3. "2Log_ready.lyr" is already time enabled and has the necessary attributes. The following sub-procedure documents how this layer file was built.
   - "YG_retype" has a column called "TwoLogYear" this attribute was populated from the FPS database and simply listed the calendar year in which each stand hits the 2-log limit. If no year is present, the stand never did hit the 2-log limit (usually due to high red alder content). The delivered FPS database contains a query called "#2LogMaturity_step3" which will build a list of each stand, the year it hits the 2-log limit and volume estimates in that year. The table "A_Yearof2LogbyStand" is a permanent record of this query that was built at the time of delivery by Terra Verde.
   - "TwoLogYear" is stored as an integer field. It must be in a date data type to use ArcMap time tools. Use the Arc GIS time conversion tool to calculate a date field from the year integer, call this field YrDate
   - Enable time in the layer with in the layer properties, be sure to click "display time cumulatively".
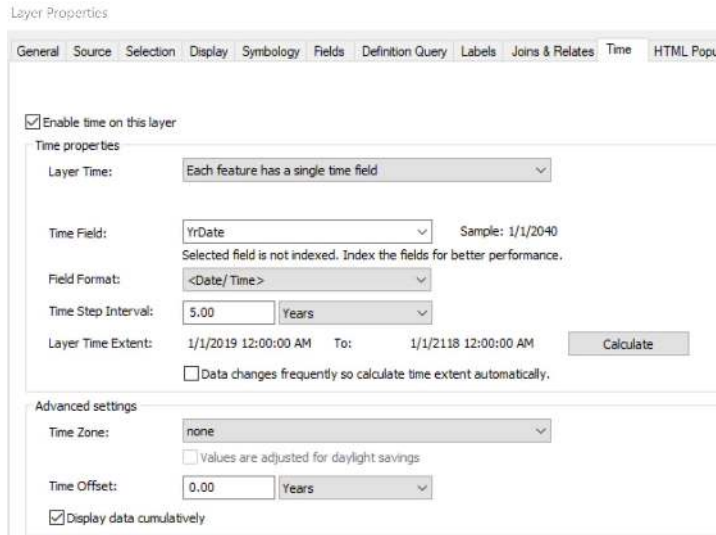
4. Click on the time tool in the tool's menu and set the step interval for 1 year at a time.
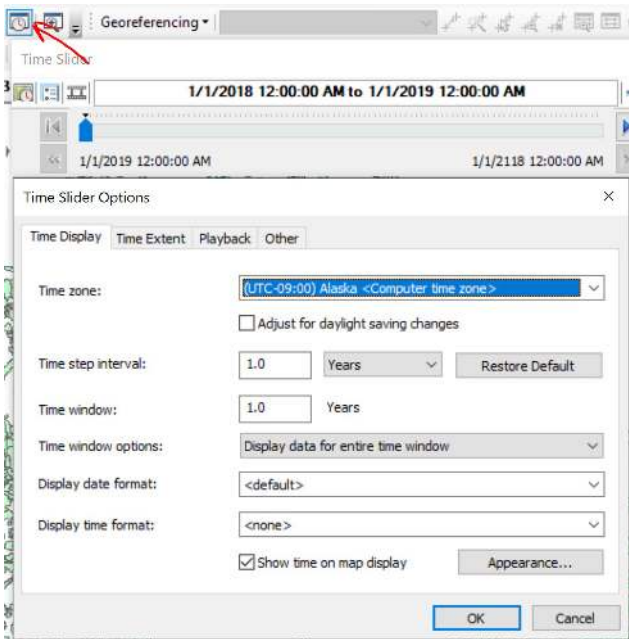
5. Move the time slider back and forth to visualize how many 2-log stands will be present on the landscape at any given point in time. The play button will perform a play through of the entire modeled timeline.
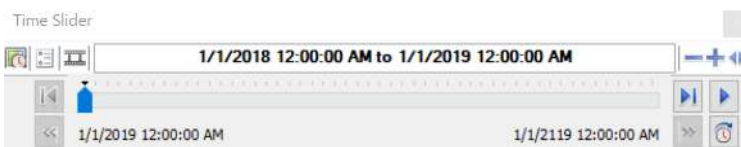
About the Author:

Brian Kleinhenz is a principal and the Vice President of Operations for Terra Verde Inc. Brian holds a BS in Biology/Environmental Studies from Ohio Northern University in Ada, Ohio and a MS in Environmental Management of Forests from the University of Joensuu in Joensuu, Finland.

Brian is very familiar with Southeast Alaska timber types and logging operations. He was principal investigator and author for this project and has over 15 years of forest industry experience in Southeast Alaska. Through his work with Sealaska Corporation, the largest log exporter in the region and under contract with public agencies, he has knowledge of export and domestic markets for both old growth and young growth timber from Southeast Alaska. He has experience across disciplines including, timber layout, timber harvest, road building, silviculture, fisheries management, wildlife management, forest policy, long range land planning and direct personnel management.

Brian has conducted timber supply analyses for land managers throughout the Western states and is a specialist in conducting these studies in SE Alaska. Brian performed a very similar analysis to this one, with inferior data and mapping, in 2011 for the JEDC hosted Timber Cluster Initiative. He provides consultation for the TNF on topics related to mapping, timber inventory, growth and yield and silvicultural planning. Brian regularly leads field based projects on behalf of Terra Verde to cruise timber and conduct project layout in Southeast Alaska. He played a major role in bringing forest-based carbon credit offset projects to Southeast Alaska.

Brian is past chairman of the Alaska Society of American Foresters, on the Board of Directors for the Southeast Alaska Soil and Water Conservation District, former Director of the Alaska Forest Association and has served as an alternate board member to the Alaska Board of Forestry.