Analysis of Young-Growth Forest Inventory Information and Future Timber Volume Estimates on the Tongass National Forest

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Tongass National Forest and State of Alaska through the FY15 Challenge Cost Share Agreement

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Foreword by: Tongass Young-Growth Challenge Cost Share Steering Committee

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Acknowledgements

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Thanks to The Nature Conservancy and Conor Reynolds who helped innovate with remote sensing technologies.

We appreciate the support of Forest Service and State of Alaska leadership at all points during this project. Members of the Tongass Advisory Committee (TAC) and Tongass Transition Collaborative deserve special accolades for concisely expressing the need for better young-growth information.

The analysis and planning tools presented here are the culmination of only one part of an extensive cooperative effort between the Alaska Division of Forestry and USDA Forest Service. This effort continues to model the principles of shared stewardship, implement the Forest Plan and related TAC recommendations, and support steps to ensure a healthy forest products industry is part of Southeast Alaska's economy. The cooperation of those acknowledged above, and many others not specifically named, has been the backbone of progress in this complex and important effort. A future summary of the comprehensive efforts taken under the CCSA and the contribution of partners to that larger effort, will further demonstrate what we can accomplish in the shared stewardship of Alaska's natural resources.

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Foreword

Introduction

This report documents how new young-growth forest inventory data was collected and analyzed, and young-growth stand mapping was updated, in the effort to better quantify and describe the young-growth forest resource as it exists across the entirety of the Tongass National Forest. Using the results of young-growth data analyses and revised mapping, the report provides:

- An estimate of the extent and character of the gross young-growth timber base across the entire forest.
- A preliminary, map-based estimate of falldown percentage in young-growth timber stands.
- An estimate of the extent of the net young-growth timber base that will be managed for future timber production and harvest.
- A projection of the potential future flow of young-growth timber volume over time.
- Descriptions of the new young-growth forest planning tools developed during the project.

The new forest planning tools, including most importantly the newly revised young-growth timber type (stand) map, along with inventory results presented in the report are expected to help the public and regional stakeholders gain a more-comprehensive understanding of young-growth timber stands on the Tongass. These new tools and information will also provide the forest products industry with information necessary to consider new investment in the region, and will enhance the ability of Tongass managers to more efficiently develop and plan future young-growth projects, such as restoration, commercial and pre-commercial tree-thinning, and timber sales to meet forest management objectives and support the on-going transition of the Tongass to predominantly young-growth management and harvest.

Background Information

The Secretary of Agriculture in 2013 directed the Tongass to transition from an old-growth dependent economy to one mainly reliant on young-growth timber. The Secretary then chartered the Tongass Advisory Committee (TAC), under the Federal Advisory Committee Act, to provide advice and recommendations on the transition. The TAC represented a broad spectrum of national, local and regional stakeholders, which provided recommendations to the Forest Service. The result of their recommendations and the best scientific data for young-growth stands available at the time of the Forest Plan amendment, suggested the transition could occur by 2031.

The TAC provided extensive recommendations to support the transition. The Tongass Young Growth Challenge Cost Share Agreement (CCSA) between the Forest Service and the Alaska Division of Forestry arose out of those transition recommendations, including the specific recommendation to complete a forest-wide, field-based young-growth forest inventory that would provide updated stand mapping and stand level data necessary to inform future young-growth planning and management activities in support of the transition.

The amended Forest Plan, based on TAC recommendations guides the agency to learn from these inventory efforts, and early project implementation, in collaboration with stakeholders. This learning has been facilitated by the efforts of the Alaska Division of Forestry, Forest Service, and various collaborative interests such as the Tongass Transition Collaborative and Prince of Wales Landscape Assessment Team.

Tongass Young-Growth Challenge Cost Share Agreement

The Tongass Young-Growth CCSA (2015 to 2020) used federal funding to complete the field-based young-growth forest inventory and related data analyses, and to create the new forest planning tools. All aspects of the project were accomplished with administrative support and technical oversight provided by a multi-agency steering committee comprised of leadership and professional resource staff from USDA State & Private Forestry, USDA Forest Service, and the Alaska Division of Forestry.

Gross Young-Growth Timber Base

New GIS (computerized) mapping identified and classified (timber typed) all young-growth timber stands across the entire Tongass. These timber stands comprise the gross acreage of the young-growth timber base.

Falldown

In the report the term “falldown” (synonymous with “net-down”) is used to describe that portion of the total acreage of young-growth forest which is not planned to be managed for future timber production and harvest. Falldown is partly the result of legislative and administrative no-harvest constraints but is also due in part to operability factors which render road construction and/or timber harvest infeasible in some areas.

Legislative falldown includes non-development land use designations (LUD II), Wilderness areas, and lands protected by the Tongass Timber Reform Act, as some examples.

Administrative falldown refers mainly to provisions of the Forest Plan which preclude timber harvest in some areas. These provisions are mostly designed to protect other forest resources. Two examples are timber retention buffers adjacent to fish streams and in areas of high vulnerability karst.

Harvest operability falldown includes those areas which cannot be feasibly accessed and/or harvested based on topography, economics, and/or the limitations of current conventional harvesting technologies.

As a result of analysis described in the report, a falldown percentage (approximately 40%) was ultimately applied to each young-growth timber stand. This figure resulted mainly from a GIS map-based analysis, but also reflects the average amount of falldown identified in 94 stands so far examined in detail by Tongass timber staff, who determined young-growth falldown can range from 5% to 90% in any given stand. These 94 stands represented some of the oldest young growth stands on the Forest and in locations with the highest potential complexity for harvest activities. It is important to note there are more falldown acres in older stands because fewer of the now-required harvest constraints were in place at the time of harvest; many of the present-day harvest constraints are designed to protect other forest resources, but were instituted more recently. As an example, early timber harvests were often conducted by means of A-frame logging in beachfront areas, but while most of those areas have since successfully regenerated and now support timber stands capable of supporting economic timber harvest, Forest Plan provisions significantly restrict harvest activities in a 1,000-foot zone immediately upland from the beach. Conversely, falldown percentages in younger stands, which originated from much more recent harvests, are often minimal and reflect the application of a greater amount and diversity of harvest restrictions that were in place at the time of harvest.

Net Young-Growth Timber Base

The net young-growth timber base is comprised of the acres remaining after the falldown acres have been set aside from the gross timber base; this net acreage more accurately reflects the actual young-growth timber base that will actually be managed for future timber production and harvest.

Non-Federal Timber Base in Southeast Alaska

While outside the scope of the report, it is important to note that in addition to the Tongass, other non-federal forest lands also contribute to the overall young-growth timber base in SE Alaska. Native Regional and Village Corporations, Alaska Mental Health and the University of Alaska land trusts, and the State of Alaska all manage significant acreage of young-growth timber stands in the region which are dedicated to commercial timber production and harvest, and it is expected these other forest lands will contribute sales of commercial young-growth timber volume both during and following the transition.

Young-Growth Timber Volume Projections

Growth and yield modeling conducted for all timber stands contained in the net young-growth timber base projected the annual volume of economic timber these young-growth stands could produce in each future year. The threshold used to determine when a stand is economic relied on an approximation of the 2-Log Rule contained in the Forest Plan. The 2-Log Rule was developed to predict when a young-growth stand could provide an economic harvest opportunity. The approximation of the Rule used in this report states a young-growth timber stand presents a potentially economic harvest opportunity when the average timber volume in the stand is at least 20.5 MBF per acre and the average height of trees in the stand is at least 90 feet; a 90-foot tree is expected to produce at least two 34-foot long logs.

The timber volume flow analysis described in the report projects young-growth stands will provide the timber volumes that meet or exceed the anticipated young-growth timber demand (estimated in the Forest Plan to be about 41 MMBF per year) beginning in the period between about 2026 and 2029. However, due to the wide geographic distribution of those stands, the ability of Forest managers to design large timber sales (30 MMBF) during this period will be challenging. Beginning in about 2030 and continuing into the future, logical timber sale areas (a basin or area tributary to an existing log transfer facility or road system) will begin to accrue larger aggregations of individual timber stands meeting the approximation of the 2-Log Rule such that design of larger timber sales will become increasingly feasible across more areas of the Forest, particularly on areas of the southern Tongass where many of the older young-growth stands are located.

Limitations of the Analysis

No direct comparisons can be made between young-growth acreage estimates contained in the report and estimates of young-growth acreage contained in the Forest Plan because each document relied on different datasets and methods to derive those estimates. Young-growth acreage estimates in the report relied on analysis of new forest inventory data and revised mapping and classification of young-growth stands not available at the time of the 2016 Forest Plan amendment.

Estimates of falldown in young-growth stands are mainly the result of GIS (computer map) analysis, and likely represent the greatest area of uncertainty within the analysis. Comprehensive and more-reliable estimates of acreage falldown will require the collection and analysis of new information, including most importantly, site-specific data and information resulting from field surveys conducted in individual young-growth timber stands. To date, 94 stands on POW Island have been analyzed with complete resource information. Those stands can be found on the Tongass Young-Growth Inventory portal:
https://www.arcgis.com/apps/MapJournal/index.html?appid=e748ce92139c4100a65ad8b12510d620

The growth and yield software relied on new stand mapping along with stand and tree-level field data. Any changes to the dataset, GIS map layers and/or any of the variables and underlying assumptions used by the software would yield significantly different results in predicted future timber volumes and timelines.

None of the analyses described in the report represent or approximate a genuine sustained-yield analysis.

Young-Growth Forest Inventory Data Collection

During the 2016, 2017 and 2018 field seasons, Division of Forestry (DOF) forest inventory crews collected field data from more than 10,000 cruise plots, located in 55+ year old young-growth timber stands, totaling more than 69,000 acres. Project analyses also used young-growth field data, most collected since 2017, from nearly 6,000 Forest Service stand examination plots established in 40 – 54+ year old young-growth stands covering about 45,000 acres. The results of an analysis completed by The Nature Conservancy relating LiDAR data to field collected tree measurements also aided in mapping and classifying young-growth stands. Young-growth inventory data results, and young-growth stand mapping are publicly available and are explained in detail within the Forest Service's Young-Growth Forest Inventory Portal, on the web at:
https://www.arcgis.com/apps/MapJournal/index.html?appid=e748ce92139c4100a65ad8b12510d620

Young-Growth Forest Inventory Data Analysis and New Forest Planning Tools

Terra Verde, Inc. was contracted by the DOF, through the CCSA, to assist the DOF and its project partners in completing several complex analyses using the young-growth forest inventory field data. Project analysis of LiDAR data, aerial photography, satellite imagery, Forest Service GIS mapping, young-growth forest inventory plot data, stand exam plot data, and other information produced a suite of young-growth forest planning tools:

- Forest-wide young-growth timber type (stand) mapping.
- Forest-wide young-growth timber stand database contained in Forest Projection System (FPS) software. FPS software was developed by the Forest Biometrics Research Institute (FBRI). More information about FBRI and FPS software can be found on the web at: https://fbrinstitute.org/.
- Forest-wide growth and yield modelling (using FPS) of young-growth timber stands, including net harvestable acreage estimates based on Forest Service corporate GIS layers.
- GIS time-lapse map tool showing predicted young-growth timber volume flow over time across all areas of the Forest.
- The 2-Log Rule Young-Growth Timber Volume Flow Report, including instructions to operate the time-lapse map tool.

New Young-Growth Timber Type (Stand) Mapping

Forest Service GIS mapping was updated using satellite imagery and recently acquired LiDAR data to more accurately depict the locations, external boundaries and acreages of all existing young-growth timber stands on the Tongass, and to clearly differentiate them from adjacent old-growth timber stands and non-forest land cover classes (e.g., lakes, roads, alpine, muskeg, bare rock, etc.). The mapping update also split large contiguous areas of young-growth forest originating from historic timber harvest into smaller, discrete timber stands that more accurately reflect differences in tree size and stand density resulting from natural variations in the quality of growing sites. Each mapped young-growth timber stand was assigned a unique stand ID and a timber type label to describe its species composition, height of overstory trees (tree size) and degree of crown closure (stand density).

FPS Young-Growth Timber Stand Database

A database containing all of the young-growth forest inventory plot data was developed and stored within FPS software which was also used to manage and analyze the data. The database includes both stand-level data and tree-level data for every stand depicted on the young-growth timber type (stand) map. Stand-level data contained in the database includes stand ID, acreage, species composition, tree size and per-acre timber volume. Tree-level data contained in the database includes all the tree measurements for each tree measured on each cruise plot, in every stand sampled during the field inventory. By linking the database file for each inventoried young-growth stand to the GIS map, stand data were expanded into un-sampled stands based on timber type labels predicted in the mapping effort. This enabled the growth and yield modelling software to simulate how each individual young-growth timber stand is expected to grow and accumulate timber volume over time, according to the influence of certain variables considered by the software.

Growth and Yield Modelling of Young-Growth Timber Stands

In addition to relying on field-collected plot data, modelled predictions of future forest growth and yield in young-growth timber stands using FPS is also predicated on several software input variables and assumptions, including relative measures of site productivity and use of a predetermined timber volume threshold. Using the best information available, an individual site productivity value was assigned to each stand for purposes of the modelling. The timber volume threshold used in the current analysis relies on the approximation of the 2-Log Rule previously described, above.

GIS Time-Lapse Map Tool

The time-lapse map tool combines the power of the GIS and FPS databases to visually illustrate, on an animated computer map, the year when each young-growth timber stand on the Forest is predicted to attain the amount of volume approximating the 2-Log Rule. This tool can be useful in determining the future year a particular geographic area is expected to contain enough merchantable timber volume, distributed throughout several young-growth timber stands, to support a potential timber sale.

Transition Recommendations

The report contains recommendations to further refine and aid in young-growth planning in support of the transition.

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Executive Summary

Young-Growth Timber Base

A detailed analysis conducted over the entirety of the Tongass National Forest (TNF) involving recently collected young-growth forest inventory data and newly created young-growth timber stand mapping produced the following estimates:

- The combined gross acreage of all TNF young-growth timber stands totals approximately 452,600 acres. The current field inventory focused on identifying, sampling and classifying young-growth timber stands that originated from historic timber harvests.
- A GIS-based analysis of potential falldown acreage estimates approximately 190,700 acres or 42% of the total TNF young-growth stand acres will not be managed for timber production and harvest due to current legislative, administrative and harvest operability constraints. Actual falldown acreage can only be fully determined following future site-specific field review of each planned young-growth timber harvest unit.
- The estimated combined net acreage of all TNF young-growth timber stands which will be managed for timber production and harvest totals approximately 261,900 acres.

This report does not attempt to make a robust comparison between methods used for this analysis and the separate methods used by the Forest Service to define “suitable”[1][1] young-growth acreage in the 2016 Forest Plan. However, net young-growth acres presented here (261,917 acres) are substantially fewer than acres defined as suitable (338,973 acres) in the Forest Plan. The Forest Plan considered all acres in certain retention and partial retention zones as suitable since thinning across the entire stand would be permissible so long as site-specific standards and guidelines are followed. By using the best Forest-wide information available and explicitly removing acres mapped in retention and partial retention zones, net young-growth stand acreage listed in this report more closely approximates the acres that will actually be managed for timber production and harvest in the future.

Economic Young-Growth Timber Volume Flow

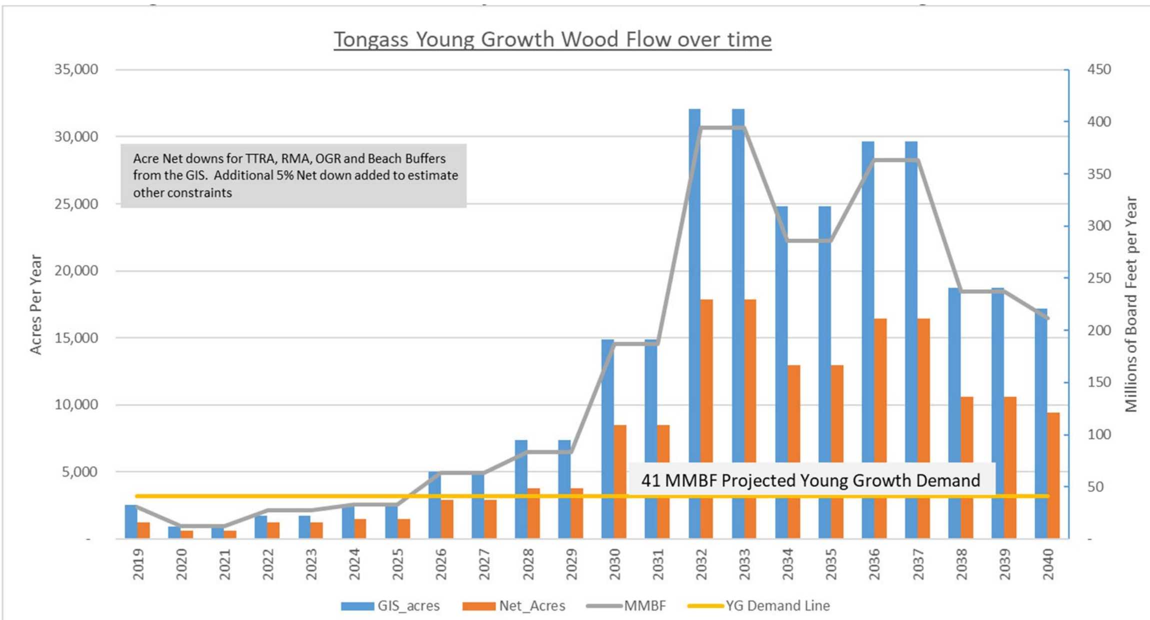
A separate growth and yield analysis involving all timber stands in the net young-growth timber base was undertaken to estimate the total volume of economically harvestable young-growth timber it could potentially produce on an annual basis. The timber volume threshold used to denote an economic harvest opportunity is a close approximation of the “2-Log Rule” contained in the current (2016) Forest Plan; the approximation of the rule used in this analysis assumes each young-growth timber stand will support economic timber harvest when it contains a minimum volume of 20.5 MBF per acre, and the average height of trees in the stand is at least 90

[1] Suitable young-growth acres are defined as such if they are represented in the SuitabilityFP16 GIS layer maintained by the Forest Service and in accordance with guidance in the 2016 Forest Plan.

feet. Annual projected demand[2] is 41 MMBF/year according to the Forest Plan. Results of this analysis show that enough stands achieve the 2-Log Rule to meet and exceed that demand in 2026, but the stands are geographically scattered, making potential sales infeasible until the year 2030. Widespread availability of stands reaching the 2-Log Rule will begin occurring in denser geographic concentrations starting in 2030. Putting together large young-growth timber sales (20 – 30 MMBF) inside the next 6-10 years will be challenging. For purposes of the graph, "GIS acres" means gross young-growth acres for each year depicted.

The analysis detailed in this report is not a sustained yield analysis, which is the process of determining the rate of harvest over time that is in balance with, and does not exceed, the growth rate of the forest. This timber volume flow report simply lists at what point in time each young-growth stand included in the net young-growth timber base will achieve the economic timber volume threshold approximating the 2-Log Rule.

Figure 1. 2-Log Rule near-term volume flow and stand acres contributing over time



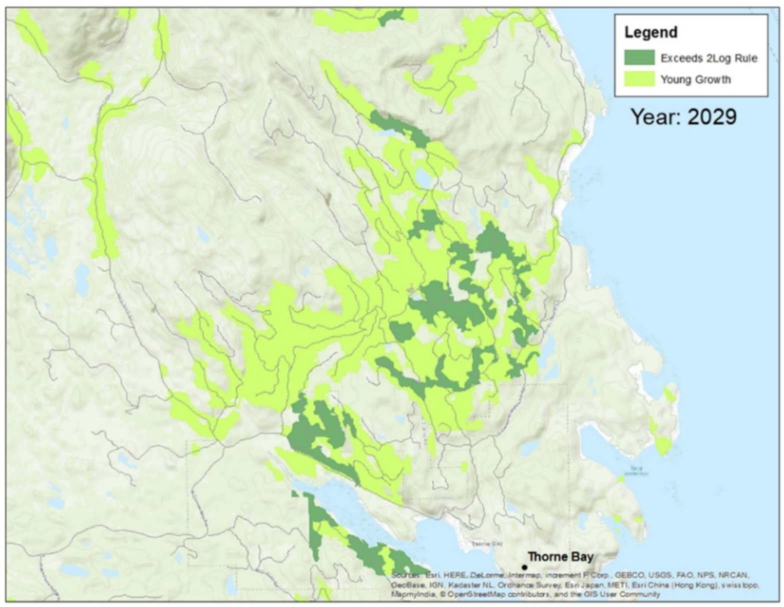
It is critical to note that the summary in Figure 1 does not take into account any of the operational considerations or factors, such as proximity of stands to one another, area-specific logging and road building costs, or a small amount of timber volume in a remote location, all of which influence the economic viability of any particular timber sale offering.

A time-lapse analysis of the Thorne Bay area suggests that it will be 2029 before 30 million board feet, contained in about 15 separate young-growth timber stands, is available in the same operational area. A timber sale of about 30 million board feet is simply a benchmark that

[2] 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.

represents sufficient volume to support a reasonably sized one-year harvest operation or a modest two-year harvest program. Operations of this size have a better chance of covering mobilization costs and have a higher likelihood of attracting competitive bidding. The innovative time-lapse planning tool (instructions provided in this report) will be especially useful in planning future young-growth timber sales in areas where more than one harvest entry is planned. There will be a need to aggregate stands into separate sale offerings and in combinations which maximize the economic viability of all sale offerings planned for that area.

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



List of Deliverables

- Analysis showing the extent of the net young-growth timber base demonstrate near-term flow of economic young-growth timber volume and detail analytical methodology.
- Fully populated timber inventory database (Forest Projection and Planning System (FPS) MS Access format) of young-growth stands with fully revised timber typing and including falldown acreage estimates for each stand.
- Geographic Information System (GIS) database with freshly mapped young-growth timber types.
- GIS database demonstrating results from preliminary falldown acreage estimates.
- GIS database listing the year each stand is projected to reach the 2-Log Rule.
- Time-enabled (time-lapse) young-growth timber type map and instructions for conducting basin-specific analyses to assist in the process of planning future young-growth timber sales.

Core Recommendations

- Continue refining acreage falldowns to reflect required protection of other forest resources and factors influencing timber harvest operability. Accurate stream protection zone mapping is paramount among these factors.
- Reinforce the existing sample dataset by collecting field data from additional forest inventory plots to fill in data gaps that now exist on portions of the northern and central Tongass, and in the younger age class stands.
- Future young-growth inventory and mapping efforts should include methodology designed specifically to more comprehensively identify and classify natural origin young-growth stands.
- Use the time-lapse tool to help identify and prioritize those planning areas which present the most feasible near-term, economic young-growth timber harvest opportunities, and begin timber sale planning activities for those areas.
- Conduct a sustained yield analysis for the entire net young-growth timber base to determine at what level harvest equals growth. This would be different from the sustained yield analysis in the Tongass Forest Plan as it would be focused on just the acres that are estimated that could be harvested. This analysis would change given any changes in the land base or standards and guides.

Background

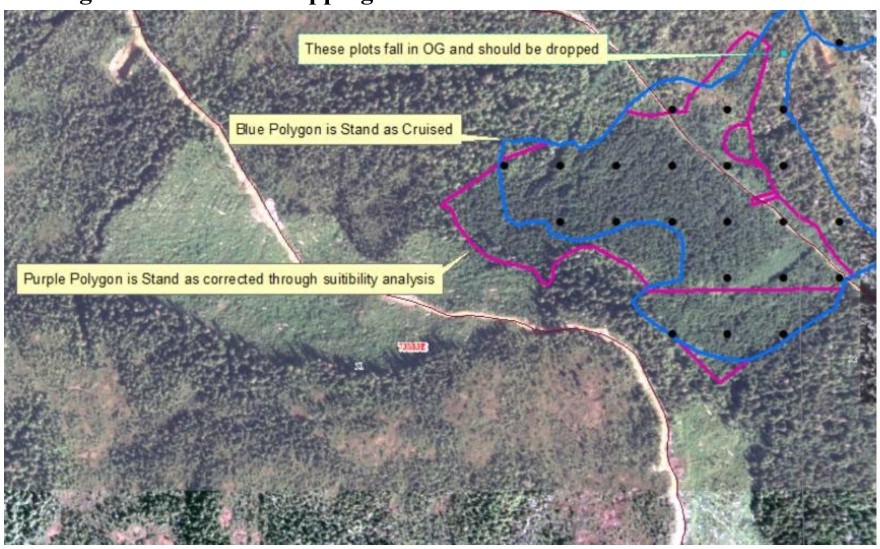
The Tongass National Forest is undergoing a programmatic shift in its timber management program to decrease the harvest of old-growth timber and increase the harvest of young-growth timber. In order to enable this transition, the TNF is updating and improving its information and planning systems to better anticipate the locations, quantities and timing of young-growth timber stands that will be available to support the goal of maintaining a timber industry in SE Alaska.

A key part of improving the base of information was partnering with the State of Alaska Division of Forestry through a Challenge Cost Share Agreement. This mechanism helped expedite the collection, evaluation, and reporting of young-growth forest inventory information. Beginning in 2016, the State of Alaska began deploying field crews to collect field data and information from forest inventory plots located in young-growth timber stands throughout the TNF. Upon completion of the field data collection, at the conclusion of the 2018 field season, the TNF staff compiled and analyzed all of the young-growth data and information and began utilizing and disseminating the results in many ways, including a novel approach of making all the data available through online mapping tools accessible to members of the public through a Forest Service sponsored website that houses the Tongass young-growth inventory portal which can be found at this link:
https://www.arcgis.com/apps/MapJournal/index.html?appid=e748ce92139c4100a65ad8b12510d620

To more-fully leverage and utilize the young-growth inventory information, and to establish a resource-based timeline for the transition to young-growth timber management, Terra Verde Inc. was engaged in the summer of 2018 to analyze the timber inventory data and information. One key aspect of the analysis involved devising a system within the FPS database to identify the year each individual young-growth stand on the TNF would achieve the economic volume threshold (an approximation of the 2-Log Rule). TNF staff assembled all GIS and plot information (including thousands of additional plots collected as part of Forest Service stand exams) to empower the analysis.

Due to recognized deficiencies in the accuracy of the existing young-growth stand mapping, the decision was made to create a new young-growth GIS stand map for use in defining the young-growth timber base and to enable other project analyses. To create this new GIS map layer, external young-growth stand boundaries were delineated, leveraging satellite base imagery, aerial photography, inventory plot data, and LiDAR data.

Figure 3 Illustration of Young-Growth Stand Mapping Deficiencies



The majority of mapped young-growth polygons were based on the original clear-cut harvest units that encompassed several different timber stands, resulting in very heterogeneous stands. To further leverage the plot data, it was also necessary to identify and delineate the boundaries of distinctly different timber types located within the external boundary of each young-growth polygon (historic clearcut).

Figure 4 depicts a young-growth polygon, where the external boundary of a historic clearcut is delineated in blue. Variations in vegetation type are clearly visible across the polygon; some areas are dominated by red alder while other areas exhibit varying levels of stocking by conifer trees. Inside the blue polygon, red lines differentiate the distinctly separate timber types which have been interpreted, delineated and classified on the basis of species composition, tree size (overall stand height) and tree density (percent crown closure). Black hash marks show the GPS locations of young-growth inventory plots. For purposes of plot data analysis, it is important to be able to compile all of the plots representing each timber type so they can be analyzed as a group.

Figure 4. Demonstrates the need to split young-growth polygons into distinctly separate ecological timber types (young-growth timber stands).

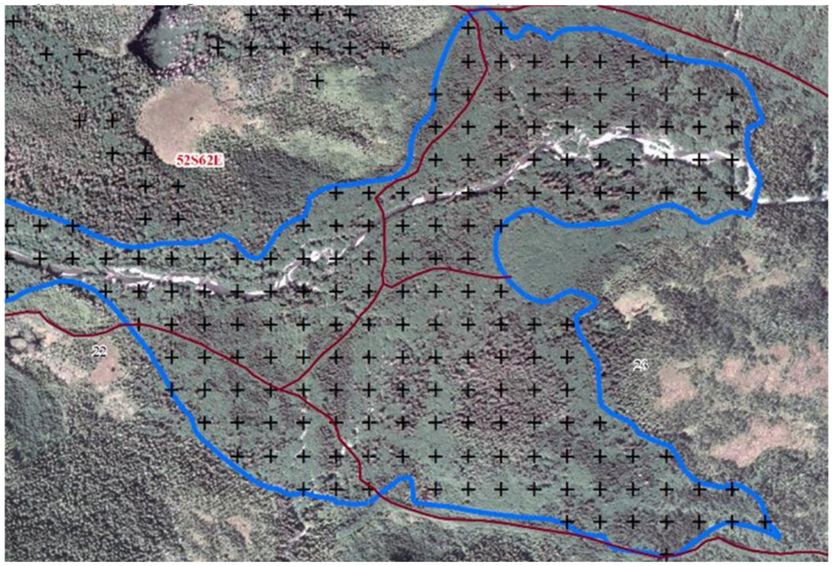
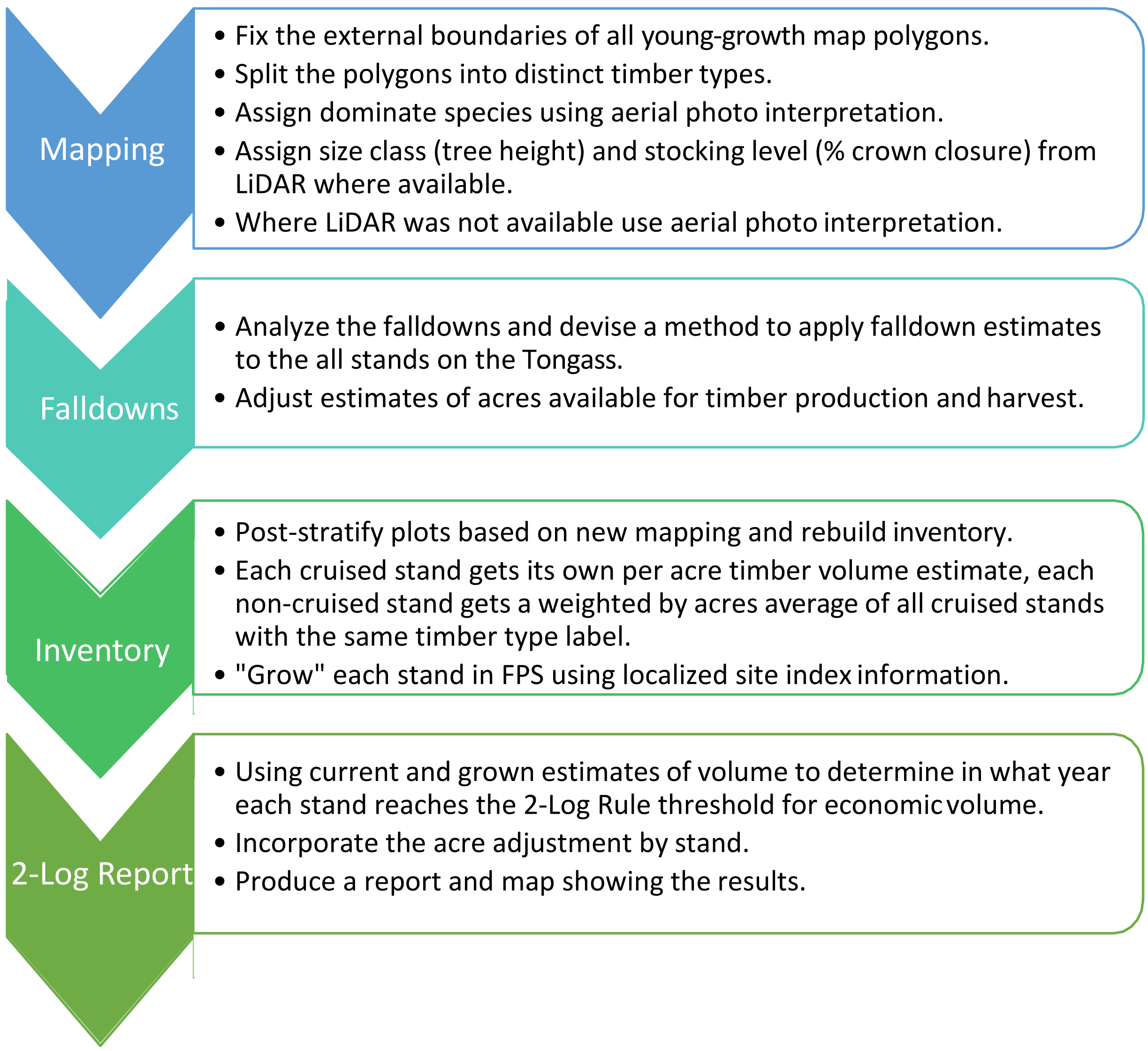


Figure 5. Workflow for turning Young-Growth Inventory Information into a Timber Flow Report



Methods

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

Mapping and Timber Typing

Management Need

TNF silviculturists required new young-growth planning tools that would not only show the location and acreage of each young-growth stand on the Forest, but would also accurately represent the full array of young-growth stand structures arising from complex and varying topography, site productivity, species composition and a range of previous management activities.

New Young-Growth Timber Type Map

The delivered product is a new GIS timber type map layer that shows each individual young-growth stand on the TNF, lists its acreage, and describes its structure by specifying (1) species composition (i.e., dominant species), (2) tree size (i.e., overstory height), and (3) stocking (i.e., per cent crown closure) in one spatially integrated attribute (timber type code). In consultation with Terra Verde, TNF silviculturists developed the following three-part, four-character timber type 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	
3rd character		CD	Strong Cedar	>40% Red and
		Yellow Cedar HS		Spruce-Hem Mix
			SS and WH in other proportions CX	
			Mixed Species	Other combinations
	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

The new GIS young-growth timber type map was developed using aerial and satellite imagery, LiDAR data, recent young-growth forest inventory plot data, and Forest Service stand examination plot data previously collected from young-growth stands.

Past stand exam plot data and information

Forest Service stand exam data, especially original harvest date, was used to reinforce confidence in timber type calls interpreted from the imagery.

Aerial and satellite imagery

Two image databases were used. The first was the USDA Forest Service digital orthophoto catalog of aerial images. Orthophotos used in the analysis had either 30cm or 1m resolution and were at least 10 years old. 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, the Tongass National Forest in Southeast Alaska.

Young-Growth Forest Inventory plot data

The young-growth forest inventory plot data used in the analysis resulted from sample plots established and cruised by the State of Alaska and the Tongass National Forest field crews via the Challenge Cost Share Agreement and stand exam work. These plots were established in a subset of young-growth timber stands by means of a systematic square grid, and the sampling frequency was one plot for every 2.5 acres. For this analysis, plot data for each stand was summarized to display dominant species composition and top height, information which aided imagery analysts in making accurate timber type calls.

LiDAR data

The LiDAR product used was acquired by the State of Alaska, The Nature Conservancy and the Tongass National Forest via their Challenge Cost Share Agreement. The LiDAR data, which was ground-truthed and analyzed by The Nature Conservancy under this agreement, covers approximately 40% of the mapped young-growth timber stands. 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

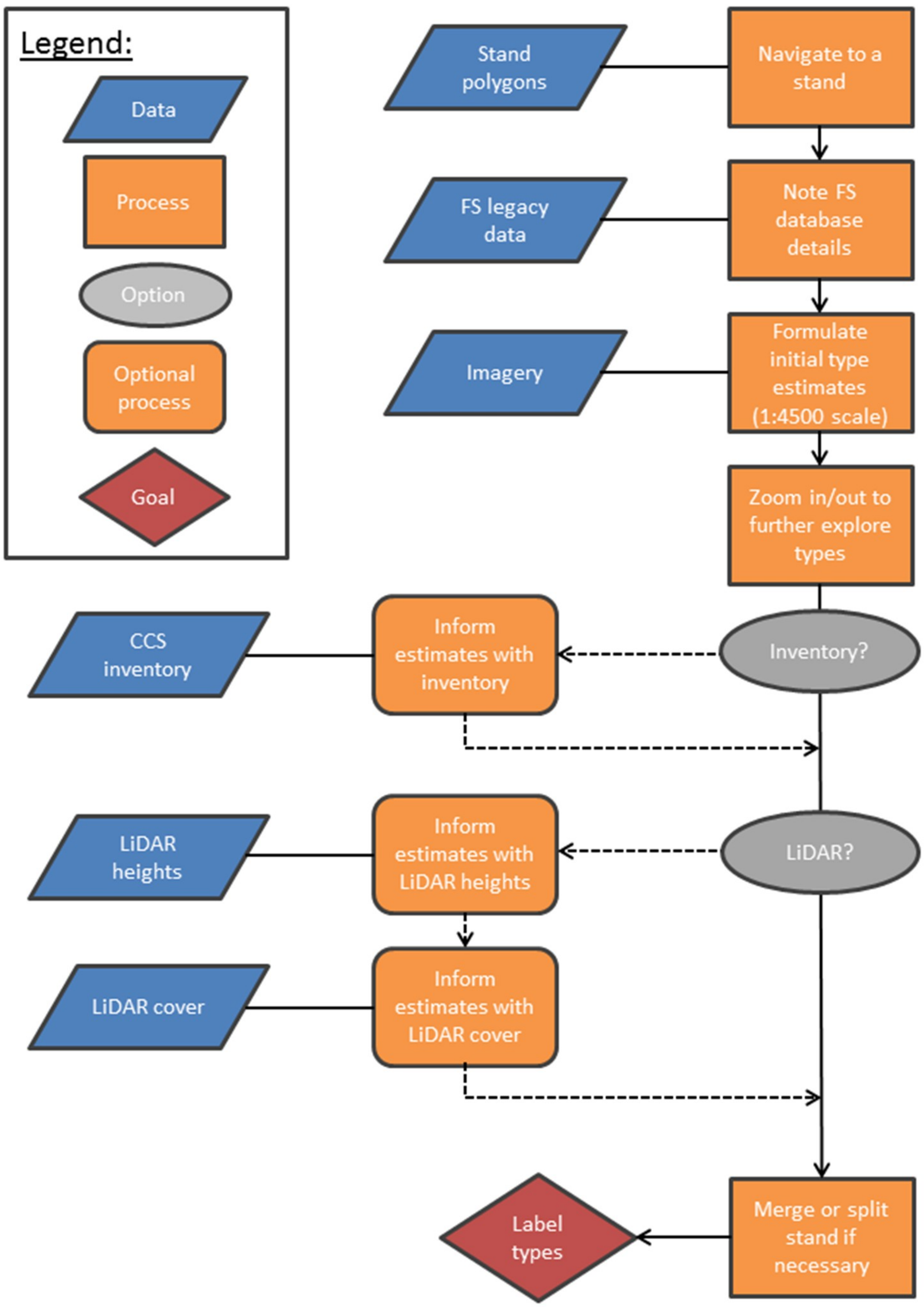
For example, if overstory height class was level 2 (45-69 ft), then crown closure class was inspected in both crown closure class 2 (26-52 ft) and class 3 (52-105 ft).

Methodological Approach

The following steps were taken to systematically and consistently classify stand species composition, tree size (stand height), and stand density (percent crown closure) for each young-growth timber stand located on the TNF.

- Using GIS, navigate to a young-growth stand (polygon) to be classified.
- Referring to stand exam or young-growth inventory data, note the date of harvest, estimate of stocking, species composition, and timber volume. Stand harvest and regeneration dates are often valuable in estimating or verifying overall stand height.
- Load aerial and satellite imagery at 1:4,500 scale or finer, depending on spatial extent of the polygon. Visually assess the polygon for significant intra-stand and/or inter-stand patterns. Assess species composition, tree height, and percent crown closure. As necessary, zoom in to further investigate these patterns. If adjacent timber stands are young-growth timber stands that also need typing, consider harvest and/or regeneration year and the practicality of current stand boundaries - if advantageous, merge stands for improved timber typing. If appropriate, split the polygon into smaller, discrete timber stands of more homogeneous species composition, average stand height, and percent crown closure, using landscape features to aid splitting whenever possible. The minimum stand size for mapping was approximately 10 acres.
- If data exists, inform imagery-based estimates using young-growth forest inventory plots.
- If data exists, inform imagery-based estimates using LiDAR overstory height classes. Where different height classes form more than one relatively homogeneous patches within a polygon, consider splitting it into two or more discrete timber stands.
- If data exists, inform imagery-based estimates with LiDAR overstory crown closure classes. Where different classes form relatively homogeneous patches within the polygon, consider splitting it into two or more discrete timber stands. Match crown closure classes to overstory height class.
- Assign a four-character timber type label to TV_CoverTypeEdit layer in the NewLbl field. These steps are summarized in the flowchart, below.

Figure 6. Flowchart outlining the TNF young-growth timber typing process.



Using Lidar Products to Validate Manual Height and Crown Closure Calls

In 2019, newly acquired LiDAR data became available and FUSION software was used to generate forest metrics for most of Prince of Wales, much of the area around Kake, and a significant area around Hoonah. Approximately 40% (209,500 acres) of the young-growth stands already classified were found to have LiDAR coverage. Standard procedure during the timber typing process was for the person interpreting the imagery to make a qualitative call manually using the best available information. LiDAR data coverage was found to be helpful for determining appropriate timber type calls and in making decisions about where to insert type break lines used to separate individual timber stands.

Once a preliminary timber type call was made for each new stand, LiDAR data was used to calculate a stand height class and crown closure class call (for all stands with LiDAR coverage). In this way, the manual, qualitative calls for stand height and crown closure could be compared to the computer-generated, quantitative calls for those attributes. 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 within 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 height class break. Table 3 illustrates the average height difference for stands that differed by one height class. 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 results for the two methods were similar, the comparison validated the manual call technique. The final timber type map contains LiDAR height and crown closure calls where coverage was available and relies on the original, manual calls in areas with no LiDAR coverage. Should new LiDAR data become available for additional areas of the Forest, this methodology could be used to refine the existing manual calls for stand height and crown closure in stands without field-generated cruise data. It should be noted, TNF staff has identified discrepancies between LiDAR heights and field measured heights in some stands with field data; the reason for this discrepancy has not yet been investigated and is not currently understood.

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

Falldown Estimates

The young-growth timber type map was designed to completely capture the extent and ecological character of all young-growth timber stands on the TNF. The final product should be considered a young-growth timber stand atlas, where each individual young-growth timber stand has been identified, delineated, classified and labeled on the basis of its species composition, stand height and degree of crown closure. Analyzing and estimating how the harvest potential of each young-growth timber stand might be impacted by resource protection measures and/or harvest operability concerns required leveraging other spatial data and information. For example, a stand adjoining a major stream might be impacted by a required timber retention buffer designed to protect fish habitat contained in the riparian zone. Each stand in the young-growth stand inventory was evaluated against a suite of potential resource concerns and harvest constraints and the net, operable acreage for each stand was estimated. **It should be noted that the falldown estimates represent the weakest component of the entire 2-Log Rule analysis.** A more detailed and site-specific analysis of resource concerns and timber operability in the young-growth timber base is under active development by TNF professionals but is not yet available for all young-growth stands on the TNF. The current falldown analysis relied on the best available Forest-wide GIS data and information provided by GIS specialists at the Forest Service's Regional Office. The current falldown analysis initiated by TNF staff should continue, and should include site-specific resource and harvest operability information as it is developed through future field survey and review.

Current falldown analysis documented in this report excluded the following areas from the net young-growth timber base available for timber production and harvest activities:

- All areas classified as non-development LUDs were excluded or netted down if partial harvest or thinning is allowable under the Forest Plan. All non-National Forest System lands, including Alaska Mental Health Trust lands, State lands and all Native and other private lands and inholdings were excluded.
- Buffer areas associated with fish streams (riparian management areas, Tongass Timber Reform Act (TTRA) stream buffers and buffers adjacent to waters otherwise deemed important for fish habitat) as mapped in the Forest Service GIS were excluded.
- Acres taken out of timber production due to existing roads (buffers described in Table 4, below) were excluded.
- 65% of acres designated and mapped in the Forest Service GIS as areas of old-growth reserve were excluded.
- 100% of acres in the first 200 feet (as measured inland from saltwater), and 65% of the acres in the remaining 800 feet of designated and mapped 1,000-foot beach buffer areas were excluded.

The following steps document the process used to analyze and estimate falldown and serve as a template for performing future falldown updates

.

Steps Used for the Falldown 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 Falldowns.
   - 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
   - Roads inside YG units are about 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 young-growth stands) and operational constraints of unknown magnitude. At the end of the GIS analysis, the falldown acreage will be increased by 5% to compensate for operational constraints and currently unmapped falldown acres. This additional 5% makes the preliminary, GIS-based falldown estimates more closely reflect the average amount of falldown typically observed by TNF staff performing the ongoing falldown analysis.

- 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 and Old Growth LUDs. 35% of the acres in these beach buffer areas and OG reserves are available for harvest.
- Multiply GISAcres by ac_factor to get the Adj_acres (or adjusted acres)
- Completely net out acres for any YG polygons that fall inside non-development land use designations.
- Non-National Forest land including areas recently traded to the Alaska Mental Health Trust (MHT) were netted down to zero acres available. In a future update it is recommended that MHT trust land be entirely removed from the inventory and mapping system.
- Unit by unit analysis on operability completed by Tongass staff suggests acre falldown is commonly between 40-50 percent after refined on the ground considerations. This analysis demonstrates a falldown of **42%, which includes a 5% general operability factor on top of all mapped harvest restrictions.** Younger stands that were included in recent mapping are not typically as heavily impacted by acreage falldowns as the older stands.
- Polygons acres are summarized by Uniq_id and a table called Ac_RPT.dbf is created and imported into the FPS database

Future analysis of falldown acreage in the young-growth timber base should continue as described above, but additional work will also necessarily entail field review and field survey to identify resources requiring protection, including but not limited to; fish and fish habitat, wildlife habitat, karst features, sensitive soils, cultural resources, botanical resources, etc. Field work will also be necessary to verify operational conditions, including logging and roading feasibility.

FPS Young-Growth Forest Inventory Database

Construction of a new young-growth timber stand database containing the recently acquired forest inventory data was necessary to complete growth and yield modeling integral to the 2-Log Rule analysis. Since the timber typing and stand mapping effort resulted in the creation of entirely new timber stands that were not considered in the original cruise design, some adjustments were necessary. Plots were re-stratified and aggregated into the 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 of the newly identified stands only encompassed a handful of plots. In order maintain the ability to calculate quality statistics, plots were removed from any stand that contained less than 3 sample plots. Once plots were re-assigned and compiled, strata level averages were calculated, and estimates were populated into all young-growth stands that were not actually field 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. Using growth and yield software in FPS, all stands were "grown" forward for 100 years in two-year increments. The primary steps and assumptions use in this process are listed below:

Steps used for construction of new young-growth forest 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.
    - Any stand without a site index point falling inside it received a call based on a nearest neighbor analysis of the closest 5 points.
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
- 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 (two 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 inventoried stands had plots with data format conflicts (some plots in each stand were Forest Service stand exam plots, and some plots were CCSA inventory plots). Choosing one set of plots to analyze in the subject stands resulted in only 1-2 plots of either format remaining in each subject stand; this was deemed an insufficient sample for purposes of the analysis. As a result, 46 plots representing 480 trees were excluded from the analysis. Took a look at the number of plots per new stand. Dropped plots from stands with only 1 or 2 plots.
6. Set up the Standards and Specifications for Log Merchantability.
   - Based on the author's experience with regional merchantability standards and cross referencing USFS standards the following specs were utilized.
   - Sitka Spruce, Western Hemlock, Red and Yellow Cedar:
     - ✓34-foot nominal log length
     - ✓Minimum log must be 8 foot long
     - ✓6-inch minimum top diameter (inside bark)
     - ✓Tree must be 9 inches at DBH
     - ✓5% reduction applied for hidden defect and breakage due to falling
     - ✓Scaled according to Columbia River Long Log Rule and requiring each tree to have a full 34-foot butt log.
   - Red Alder and Lodgepole Pine.
     - ✓All volume for these species was removed as there is currently no active market.
   - It should be noted that merchantability specs are always in flux. Log lengths, top diameters and even which species are merchantable is subject to change from year to year and sale to sale. The specs chosen are a good approximation of young-growth merchantability standards in Southeast Alaska over the last decade.
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.

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".
   - A total of 16,296 plots went into the analysis
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	10,571	380,777
Cruised Stands	1,303	71,854

- 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 based on Forest Service local knowledge:

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

	SPECIES	TREES	DBH	HEIGHT
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 thins 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.
    - 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
    - **Appendix 2** contains reports summarizing final statistics for Strata within each Tract.
14. There are numerous stands that had residual/reserve (RT) trees recorded in the plot data (RT in group column of plot table). The volume for residual trees is included in the gross volume but backed out of the net volume. This lowers the stand total volume as the assumption is that these residual trees will not be logged on the next entry. Whether or not residual or remnant old-growth trees can be harvested will have an impact on the total net volume projected for harvest and will also impact the timing of the 2-log condition. Although these trees were field designated as “RT” there is no current management direction that prohibits cutting residual/reserve trees in the future and as such it may be reasonable to include this volume as basin-by-basin analyses are performed.
15. An update to the report and analysis was completed after several rounds of constructive feedback from TNF staff. The following updates were integrated to a final version of this report:
    - Added 1,293 plots that were overlooked during version 1 of the report. These plots were mostly located in the northern and central regions of the Tongass.
    - Re-expanded and generated new growth projections for any stands and strata that were impacted by the inclusion on new plots.
    - Replaced site index estimates for just over 500 stands with more-refined estimates and created new growth projections for these stands.
    - Backed out approximately 13,466 acres that were previously classified as natural origin young growth but deemed by TNF staff not to be young growth.
    - Completely re-ran the acre falldown analysis to better align with guidance from TNF staff including removing all non-development LUDs and allowing 35% removal in old-growth reserves and 1,000-foot beach buffers.
    - Removed lands traded to the Alaska Mental Health Trust.
    - Added several young-growth units identified by TNF staff.
    - Made various refinements and inclusions to the body of this report to better document the process of the analysis and the results. This includes the Statistics

Appendix, discussion of residual trees and more detail around merchantability assumptions.

2-Log Rule Report

Once the young-growth inventory database was built and the stand acres were 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 large enough and tall enough to achieve 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 two 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 ≥ 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 some reasons could be due to high hardwood components, very low site index values, or high levels of reserve trees in the stand. 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 create a copy of the YG_retype with time enabled and a filter for 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

Young-Growth Stand/Timber Type Mapping

The new young-growth stand mapping, complete with acreage and a timber type code for each stand, defines the extent and the current condition of the young-growth timber resource on the TNF. There are approximately 452, 600 acres of young-growth timber stands on the Forest, of which an estimated 261,900 acres are expected to support timber production and harvest activities.

Table 7. Acres by Vegetation Label.

VEG_LBL	GIS Acres	Net Acres
CD13	2,217	1,569
CD22	727	351
CD23	1,528	897
CD33	426	196
CX01	55,937	43,192
CX11	28,322	20,465
CX12	56,462	37,675
CX13	29,421	18,432
CX22	25,280	16,113
CX23	42,878	20,892
CX32	2,461	997
CX33	18,686	5,698
CX42	1,111	305
CX43	1,667	756
HS13	31,023	17,688
HS21	3,376	2,046
HS22	10,104	5,641

VEG_LBL	GIS Acres	Net Acres
HS23	59,552	37,317
HS32	2,337	562
HS33	32,089	13,201
HS43	2,056	769
RA22	607	173
RA23	10,344	2,700
RA32	222	16
RA33	7,147	1,516
SS23	11,471	6,005
SS32	1,245	689
SS33	8,565	3,569
SS43	675	137
WH13	2,564	1,475
WH23	1,451	790
WH33	681	86
Totals	**452,631**	**261,917**

Economic Young-Growth Timber Volume Flow

The end result of this analysis is a Forest-wide map displaying every young-growth timber stand on the TNF along with a corresponding estimate of the future year each individual stand is projected to achieve the economic volume threshold approximating 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 young-growth stand maturity and harvestability, Figures 7 and 8 demonstrate when young-growth timber volume becomes available in abundance. Before 2026, only scattered stands that were the product of early logging or logging on highly productivity sites start to exceed the 2-Log Rule. Kosciusko Island contains the largest cluster of merchantable young-growth timber stands available today in 2020. At the time of this report, the TNF is already operating an active restoration project which includes timber harvest on those acres in conjunction with the State of Alaska via a Good Neighbor Authority (GNA) project. Other areas of abundant young-growth gradually come online after 2026, with widespread young-growth harvest opportunity beginning in 2030.

Figure 7. Forest-wide 2-Log Rule Young-Growth Timber Volume over time

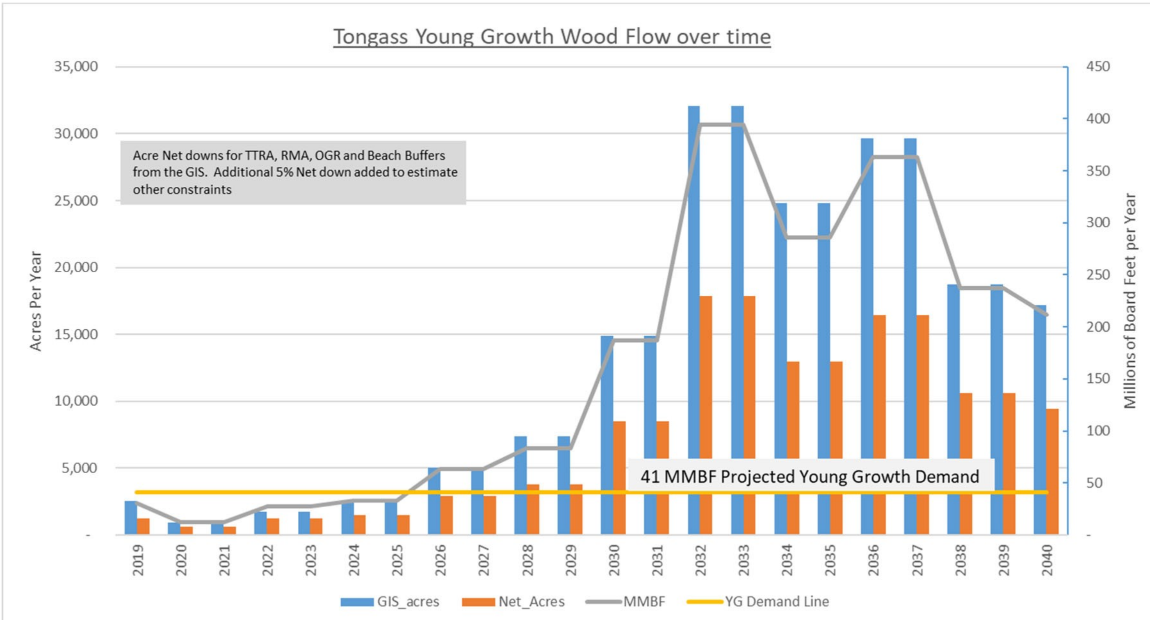
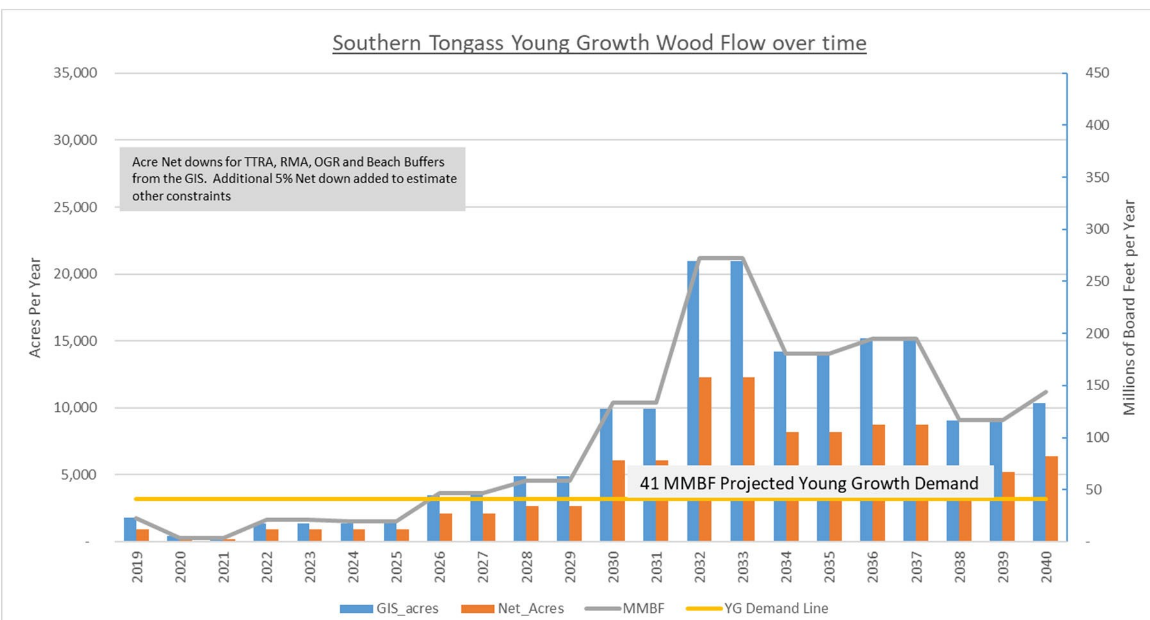


Figure 8. 2-Log Rule Young-Growth Timber Volume over time, for only the oldest stands located in the Southern Southeast, Alaska



Discussion and Recommendations

Strengths and Weaknesses of the Current Young-Growth Inventory Sample

- Sample plots established and cruised on Prince of Wales Island and in other areas of the Southern Tongass adequately describe the oldest and largest of the young-growth timber stands in that area.
- The current sample has been bolstered by using recent LiDAR data; LiDAR was used to estimate total stand height in those stands not actually field sampled as part of the field inventory.
- Due to relatively fewer sample plots located and cruised on the northern and central Tongass, the sample for these areas is statistically weak; the reliability of inventory results for this area is therefore more limited, and its use for young-growth planning should be undertaken with a degree of caution. If young-growth timber sale planning on northern and central Tongass Ranger Districts is a goal, additional inventory sample plots should be located and cruised in those areas to bolster the statistical reliability of the dataset.
- There is very little field data available for young-growth stands in the years immediately following logging. Additional data acquisition in younger aged stands in all geographical areas of the Tongass would improve the database significantly.
- Data from young-growth stands following precommercial tree thinning (stands between 15 and 30 feet tall) is completely absent from the current dataset. Attempts were made to import data from PCT contract compliance inspections without success. Contract compliance data lacked adequate plot location information and did not contain key tree attributes. However, there is a significant opportunity to collect future PCT contract inspection data that would also feed into the young-growth forest inventory system. This work flow should be evaluated. Alternatively, plots should be established and cruised in stands where precommercial tree thinning has recently been completed.

Area Falldown Estimates: The Greatest Gap in Existing Information

- Work completed by TNF staff to date suggests the falldown of young-growth stand acres typically ranges between 5%-90% with an average-falldown of around 40%. That level of falldown represents a significant reduction between the young-growth stand acres on the landscape and those young-growth stand acres that will actually be managed for future timber production and harvest. The actual net acres available for timber management will have a far greater impact on future volume available for harvest than any of the inventory information or assumptions that went into this report. The highest priority for future young-growth timber management should be to accurately define the scale of this falldown and to prevent any additional loss of acreage due to unnecessary area restrictions, including partial harvest restrictions. At approximately 261,900 acres of unrestricted young-growth available for timber production and harvest, the TNF is not left with a very large young-growth land base to support a viable timber industry. Every acre of the net young-growth timber base must be maximized if timber management is to remain among the management goals supported in the Forest Plan.
- Additional LiDAR coverage should be obtained for areas of the TNF not already covered, and LiDAR derived contour maps should continue to be used to evaluate existing logging

system/transportation analyses. Similarly, TNF staff should continue to use LiDAR data products to model and map streams and areas of high-vulnerability karst in order to prioritize areas requiring field surveys necessary to identify fish stream and karst buffers. To the greatest extent possible, remote sensing and resource modeling technologies should be utilized, in tandem where feasible, to predict resource concerns and to prioritize the work of field crews engaged in on-the-ground surveys of other resources in support of young-growth timber sale layout. Early and stable estimates of logging feasibility, roading feasibility, and harvest-restricted areas will assist in the early stages of young-growth timber sale planning and also help minimize large acreages of unpredicted falldown during the field implementation phase of young-growth timber sale planning.

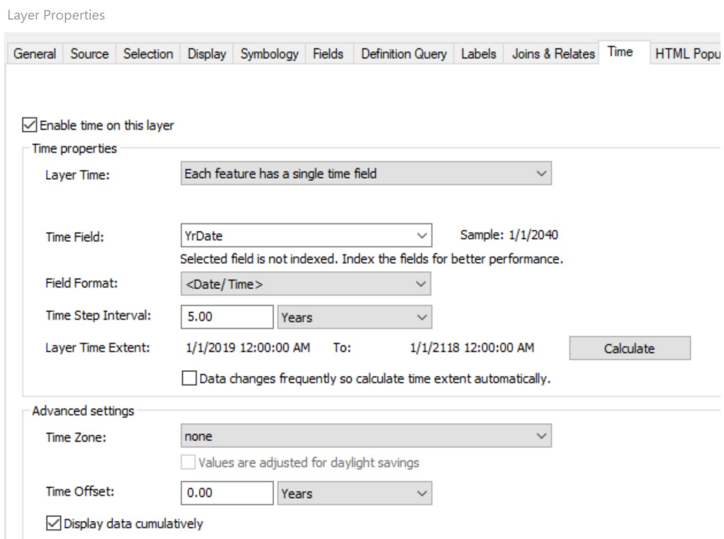
Next Steps with Analysis to Better Inform Decision Makers

- A missing component in the understanding of the Tongass young-growth resource is a sustained yield analysis. Existing young-growth forest inventory information combined with the falldown acreage estimates could form the basis for that analysis, especially since the database provided through this project is already configured to support such an analysis. A sustained yield planning process will mitigate the risk of over harvesting or under harvesting in any given year and will help avoid gaps in timber supply over the course of a rotation.
- GIS technologies and capabilities can be used to conduct robust space-time analyses. Procedures should be devised to help answer overarching questions about the quality and timing of the net young-growth timber supply. With the base inventory information so far delivered, TNF staff can identify areas that will provide 30 million board feet (MMBF)of available timber on the same road system or tributary to the same log transfer facility: individual young-growth timber sale volumes between 20 and 30 MMBF are generally considered by industry to be adequate in terms of necessary timber sale investment and development costs, including move-in and move-out costs. Changing market conditions and interest in young-growth could change how large sales need to be in the future. A prioritized listing of young-growth timber sale areas presenting the best economic harvest opportunities should be developed and maintained so field reconnaissance and resource survey efforts can be directed most effectively. This list of young-growth timber sales should take into account opportunities to combine sales with the State of Alaska, using the Good Neighbor Authority to provide for larger sales.
- Federal, Trust and State of Alaska forest managers should also expand collaborative efforts with private forest landowners in SE Alaska to gain a better understanding of how non-public young-growth timber resources may contribute to the transition on the Tongass and how the private timber base, in combination with public sources of timber, might help sustain a regional forest products industry in the future.

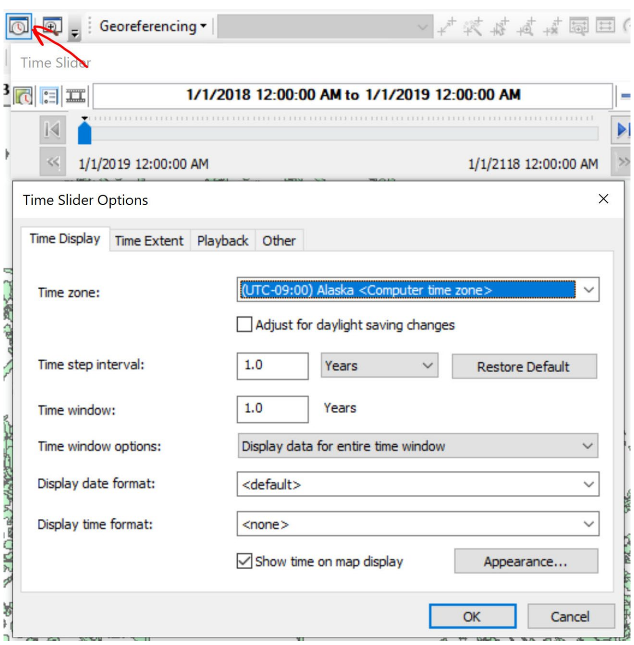
Appendix 1: Using the Time-Lapse 2-Log Rule Map to View Volume Flow Over Time by Geographical Area

This following procedural instructions 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 Rule" threshold as an indication of when each individual young-growth stand 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

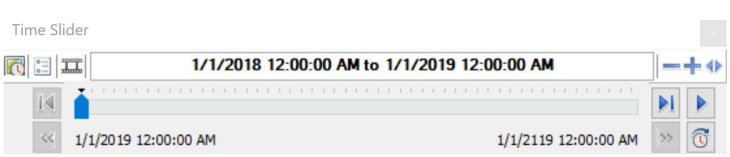
1. Open ArcGIS and set up a Map Document with relevant base layers, such as roads, imagery, shoreline and streams.
2. Add the layer called "2Log_ready.lyr" which was delivered by Terra Verde Inc as part of the final "2-log" deliverables. This layer file points to the GIS dataset "YG_retype" which was 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.



Appendix 2: Statistical Reports

Statistics of Tongass Young-Growth Inventory for Various Levels of Geography (at 1 Standard Deviation)

Flag	NumPlots	NumStds		Acres	TpaErr	BAErr	CubErr	BrdErr
All YG Combined	15,571	1,273		70,282	1.45	0.46	0.55	0.89
Northern	1,324	111		6,278	5.34	1.71	2.08	2.98
Central	3,286	323		15,541	2.60	1.05	1.17	1.86
Northern and Central Combined	4,610	434		21,819	2.42	0.89	1.03	1.58
Southern Tongass	10,961	839		48,463	1.81	0.53	0.65	1.07

Statistics of Tongass Young-Growth Inventory by Vegetation Type for the Northern and Central Tongass (at 1 Standard Deviation)

Veg_Lbl	NumPlots	NumStds	Acres	TpaErr	BAErr	CubErr	BrdErr
CD13	16.00	2.00	86.75	14.20	16.25	18.71	76.00
CD22	8.00	1.00	34.06	51.92	8.74	11.95	19.96
CD23	30.00	3.00	93.80	15.43	14.74	16.16	30.52
CD33	10.00	2.00	23.92	37.54	29.26	43.46	55.71
CX12	212.00	24.00	1,184.88	6.02	4.27	6.33	15.06
CX13	82.00	16.00	646.02	10.77	8.74	10.75	22.22
CX22	200.00	23.00	1,059.09	6.69	4.45	6.24	13.19
CX23	1,784	135	8,169	4.26	1.24	1.55	2.85
CX32	4	1	9	9.10	15.87	21.21	38.72
CX33	856	63	2,506	3.84	2.42	3.62	4.51
CX43	14	1	25	19.81	16.14	16.94	19.77
HS13	241	30	1,590	8.17	3.39	4.52	9.30
HS23	3,143	237	16,535	2.95	0.92	1.13	2.14
HS33	1,917	120	6,302	2.97	1.13	1.31	1.79
HS43	130	10	310	6.24	4.10	4.42	5.06
RA23	330	27	1,529	15.19	3.38	3.80	5.79
RA33	229	23	840	4.90	3.19	3.38	4.76
SS23	440	41	2,489	8.11	2.50	3.31	5.06
SS33	697	37	1,884	6.41	1.84	2.13	2.75
SS43	39	2	98	12.62	11.80	14.20	15.93
WH13	31	4	219	30.49	10.39	22.48	42.08
WH23	49	8	276	12.68	4.00	5.83	13.42

Statistics of Tongass Young-Growth Inventory by Vegetation Type for the Southern Tongass (at 1 Standard Deviation)

Veg_Lbl	NumPlots	NumStds	Acres	TpaErr	BAErr	CubErr	BrdErr
CD13	154	14	718	5.32	5.53	8.02	13.91
CD22	7	1	18	28.46	21.38	19.53	45.09
CD23	210	18	667	5.72	3.75	5.26	9.53
CD33	148	7	377	5.23	3.80	4.94	6.66
CX12	41	7	364	17.97	12.40	17.09	34.18
CX13	465	49	3,438	5.44	3.31	4.42	10.59
CX22	17	3	59	17.48	14.63	15.53	24.10
CX23	1,784	135	8,169	4.26	1.24	1.55	2.85
CX32	4	1	9	9.10	15.87	21.21	38.72
CX33	856	63	2,506	3.84	2.42	3.62	4.51
CX43	14	1	25	19.81	16.14	16.94	19.77
HS13	241	30	1,590	8.17	3.39	4.52	9.30
HS23	3,143	237	16,535	2.95	0.92	1.13	2.14
HS33	1,917	120	6,302	2.97	1.13	1.31	1.79
HS43	130	10	310	6.24	4.10	4.42	5.06
RA23	330	27	1,529	15.19	3.38	3.80	5.79
RA33	229	23	840	4.90	3.19	3.38	4.76
SS23	440	41	2,489	8.11	2.50	3.31	5.06
SS33	697	37	1,884	6.41	1.84	2.13	2.75
SS43	39	2	98	12.62	11.80	14.20	15.93
WH13	31	4	219	30.49	10.39	22.48	42.08
WH23	49	8	276	12.68	4.00	5.83	13.42
WH33	15	1	41	17.40	11.77	12.32	14.56