NSC 2020 Winter Conference:

How to Meet the Demands of our Changing Forests?

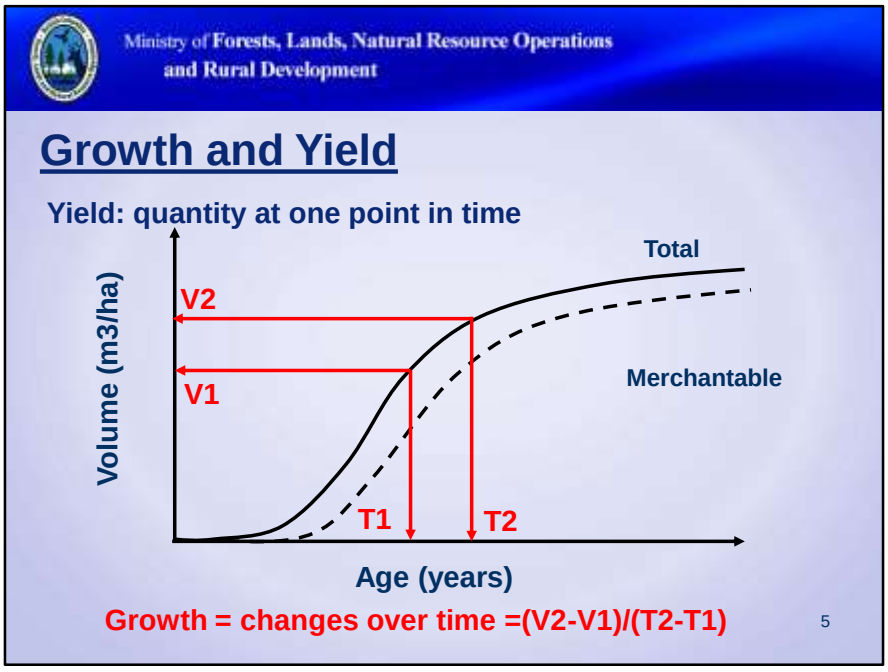
February 25-26, 2019

Important Copyright Information

The Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) uses a suite of growth and yield (G&Y) tools for (1) inventory updates, (2) silviculture decision making and (3) timber supply analysis. It is important that forest professionals working across the province are aware of the Ministry's latest (or updated) GY tools. Thus, the main objective of this talk is to provide an overview of the primary GY tools and their operational uses to support informed use of GY information and tools in BC. In the beginning of my talk, I will quickly describe the primary GY tools and their operational application. Then, I will showcase the use of Tree and Stand Simulator (TASS) for assessing tree and stand response to commercial thinning.

This is an overview of general principles to support informed use and to supplement hands-on software training. e.g., the TIPSY tutorial video on FAIB's GY website. The information presented here is subject to change as tools and techniques constantly evolve.

- The stand development process is somehow deterministic
- There are some random factors that affect the stand development over time
- Some of the random variations are considered in the model and some are not
- More data and the understanding about the random component is necessary for better predicting stand growth and yield

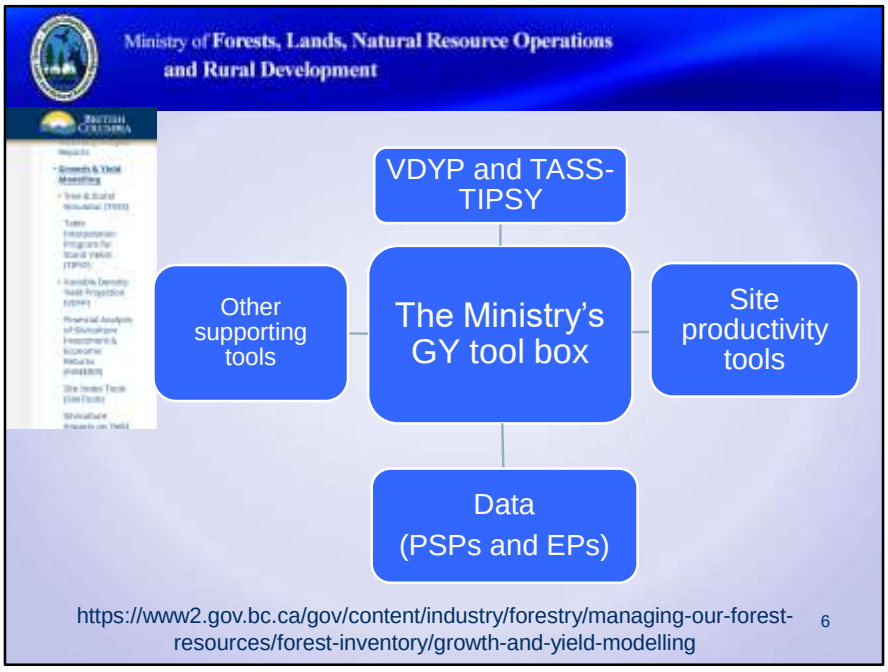


GY is used for more than just timber production. GY also predicts future stand structure attributes that drive other models, e.g., wildlife habitat, visual quality, watershed, etc.

The natural birth and death of trees are largely stochastic events, which makes them much harder to predict than the growth in between.
Yield:

- Bole volume (total, merchantable)
- Log and lumber volume

- Biomass and carbon
- Stand structure attributes for non-timber values

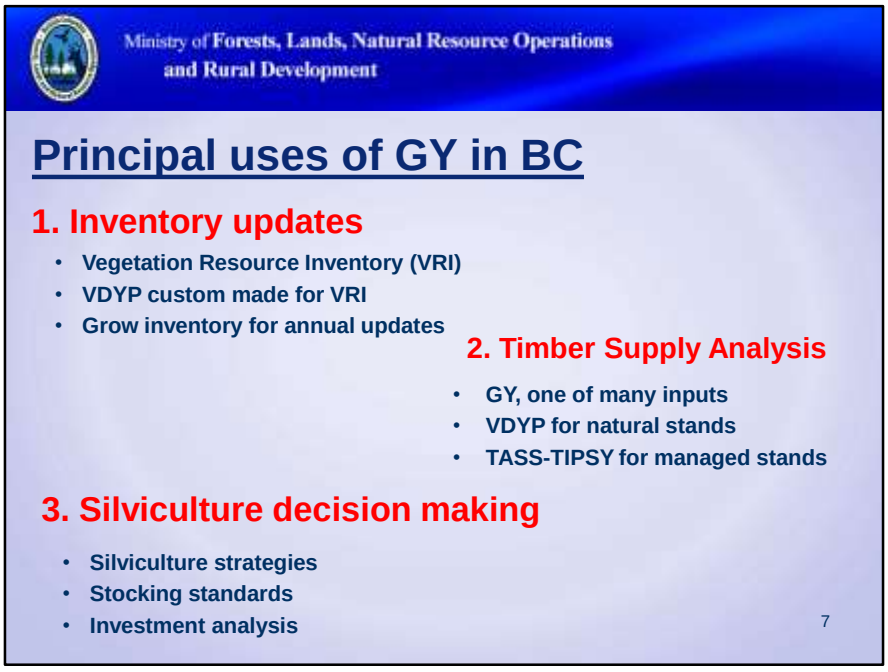


The BC government has maintained a GY research program since 1921, in support of its long-term stewardship responsibilities.

Other models exist in and around BC, but have yet to see significant operational use here. In part, because the ministry tends to be most familiar with its own models. They are also expensive to develop and support for BC conditions.

SiteTools software integrates access to most of BC's site index tools, except SIBEC which has online access. SI functions are also built into VDYP and TASS-TIPSY.

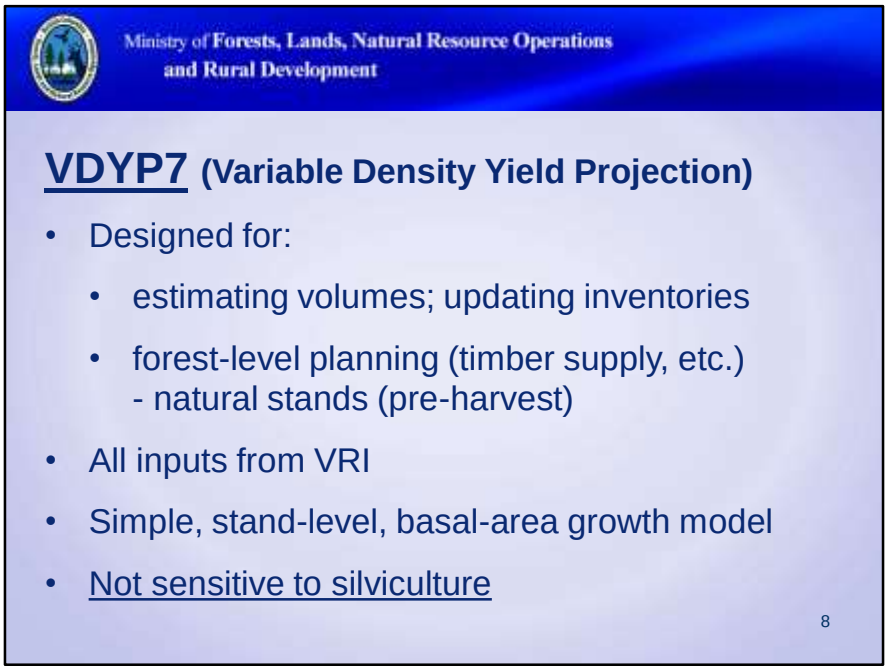
12,000 PSPs and EPs represents individual plots within installations, both active and inactive. Many other types of GY data are also collected.



VRI (Vegetation Resources Inventory) is BC's provincial forest inventory protocol. VDYP was designed to fit the VRI hand-in-glove. VDYP derives estimates for the things that are not measured or estimated directly by VRI. VDYP is used to "grow" the inventory annually between re-inventories. More about VDYP later.

TASS and TIPSY are used extensively in BC for silviculture. VDYP is not sensitive to silviculture. FFT (Forests for Tomorrow) is a provincial silviculture funding program in BC that uses GY for investment analysis. Climate change initiatives also use GY models to predict and manage forest carbon sinks.

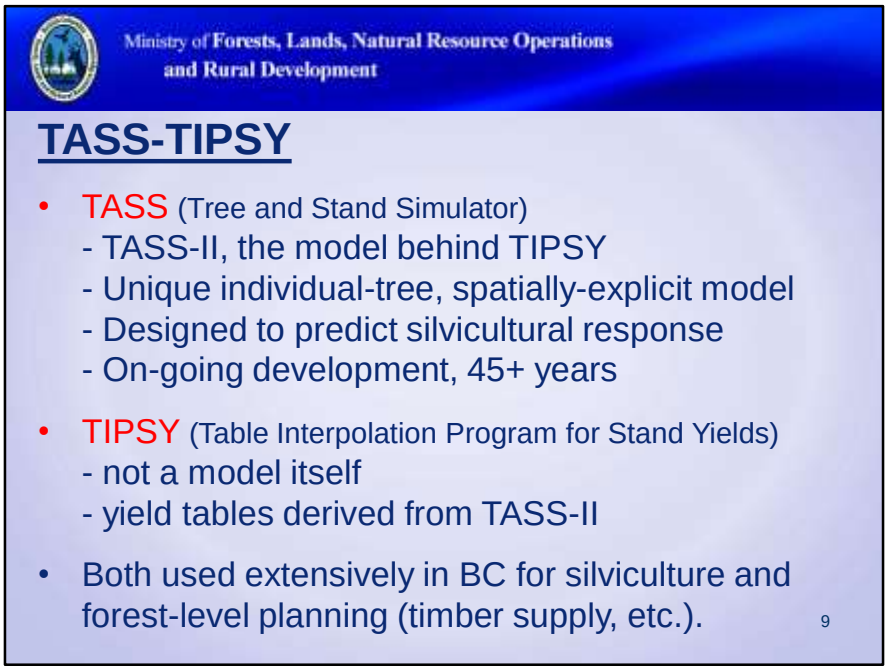
Timber supply analyses are conducted regularly to determine AACs (Allowable Annual Cuts) for public-forest management units in BC. AACs have major economic, social, and environmental implications at large scales. Consequently, GY is only one input. GY also plays a role in national carbon accounting models.



VRI inputs include: age, height, site index, species composition, basal-area, BEC zone

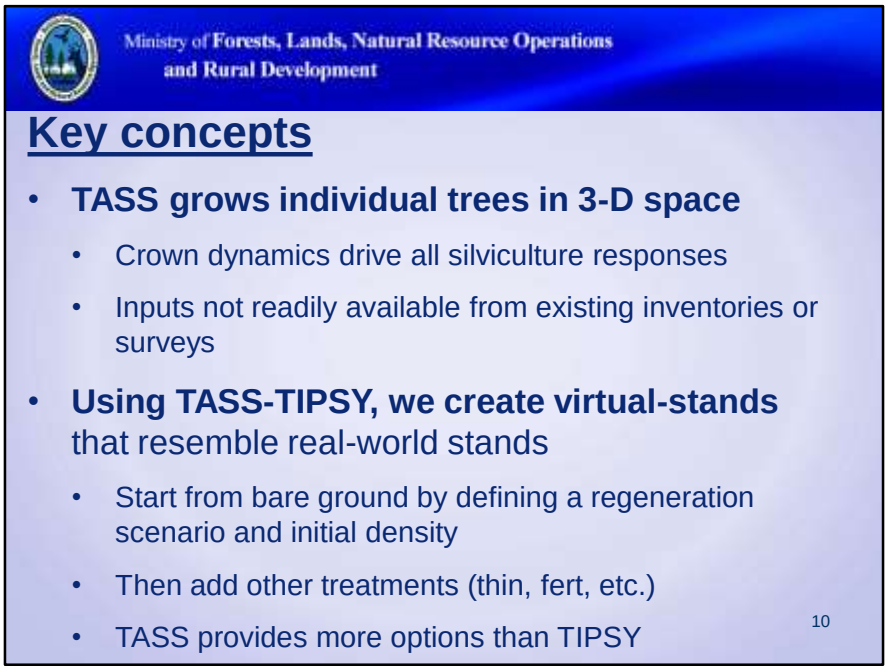
Basal area per hectare is the primary growth variable in VDYP, but it is difficult to photo-interpret. Consequently, field visits and ground plot data may be needed to support these estimates. The model can also use crown closure if basal-area and/or trees/ha are missing.

Not sensitive to silviculture treatments like TASS-TIPSY. VDYP use is simpler than TASS-TIPSY, which has far more input options. See VDYP website for more info.



TASS is a computationally-intensive model that predicts growth of individual trees relative to their spatial location and proximity to neighbours.
Bole growth is a function of crown size and crown dynamics. This crown focus provides a biologically-based link to silvicultural response.

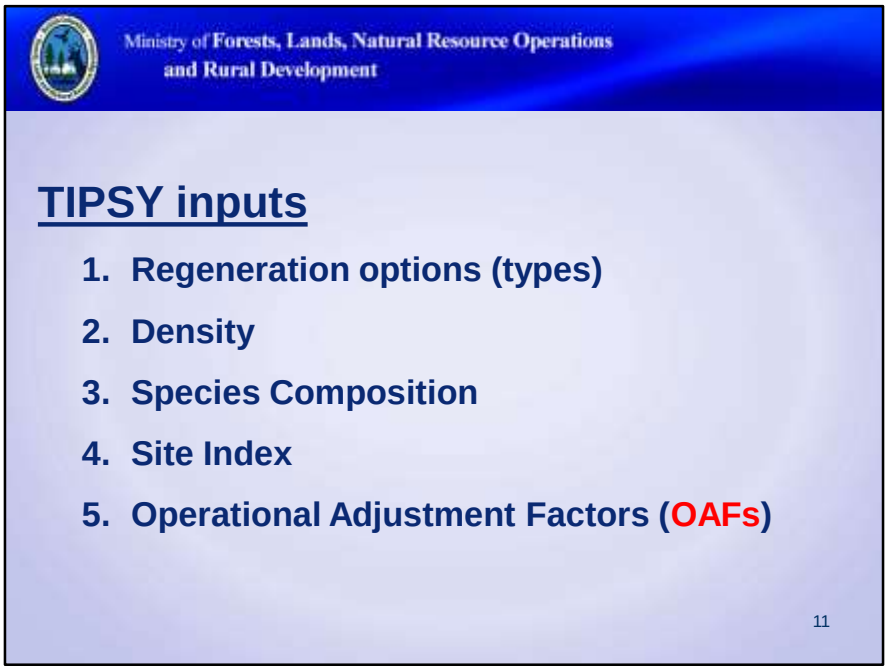
TASS-II (second gen) is the model behind TIPSY. TASS-II is primarily single-species, even-age, so TIPSY is, too.
TASS-III (third gen) is being developed for complex stands.
TIPSY has some yield tables derived from TASS III also (i.e. Pl and Sw)
TIPSY was first created in 1991 to provide timber supply analysts with easier access to TASS yield tables. Consequently, BC became one of the first provinces to extensively apply managed stand yield curves in timber supply analyses. Prior to this, post-harvest managed stands were projected with models (e.g., VDYP) developed for existing natural stands. TIPSY use enabled timber supply analyses to reflect the positive impacts of basic silviculture for the first time (i.e., density management via planting). TIPSY's effect on long-term timber supply projections is largely taken for granted now.



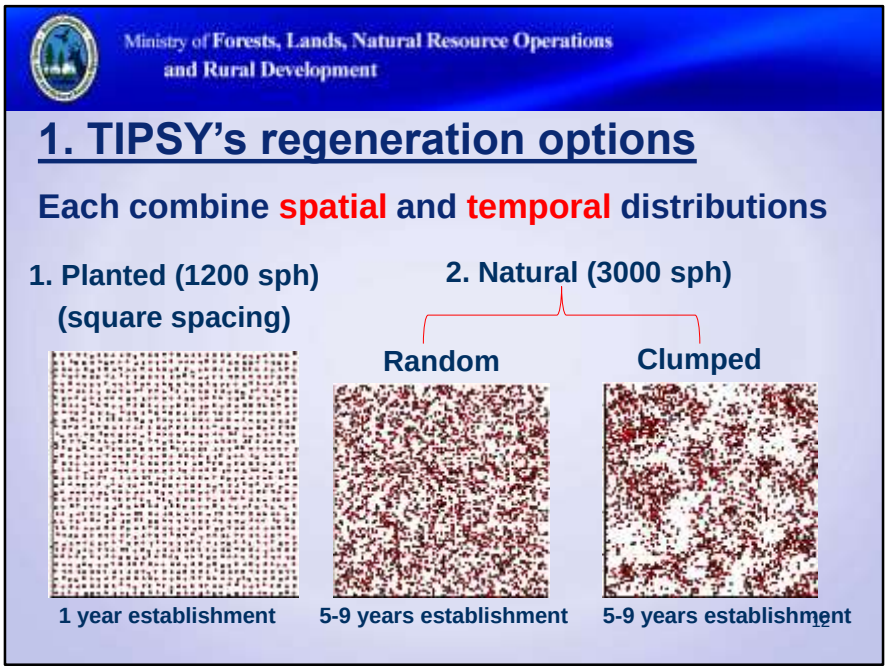
Unlike VDYP, TASS and TIPSY can't simply rely on VRI for inputs.

TASS is a complex, individual-tree, spatially explicit model. It models individual trees in a 3-D growing space in order to model the crown dynamics driving silvicultural treatment response. Inventories and surveys don't provide this level of detail. Instead, we create a virtual-stand from bare ground in TASS-TIPSY that closely resembles the real-world stand.

TIPSY's database is large, but it only contains a small fraction of the permutations and options available in TASS itself. Flexibility is limited.



Unlike VDYP, TIPSY can't simply rely on VRI for inputs. Knowing what TIPSY inputs represent helps to evaluate various sources.
TIPSY's database is a large matrix of TASS yield tables that only contain a fraction of the options available in TASS itself. Flexibility is limited.

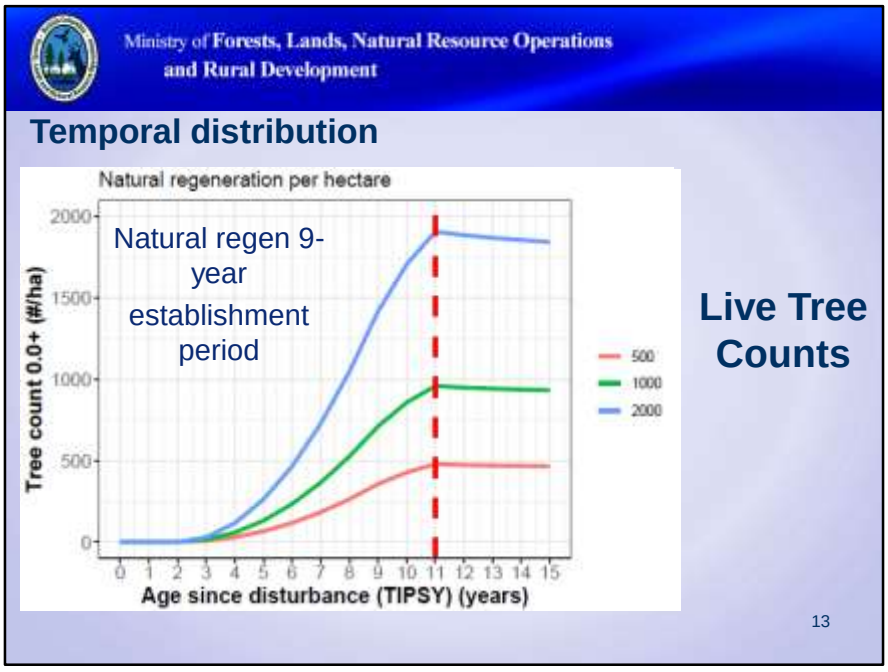


The 3 options are mutually exclusive. They can't be combined.

Planted
- single-year establishment period
- only option allowing genetic gain
- no accommodation for ingress

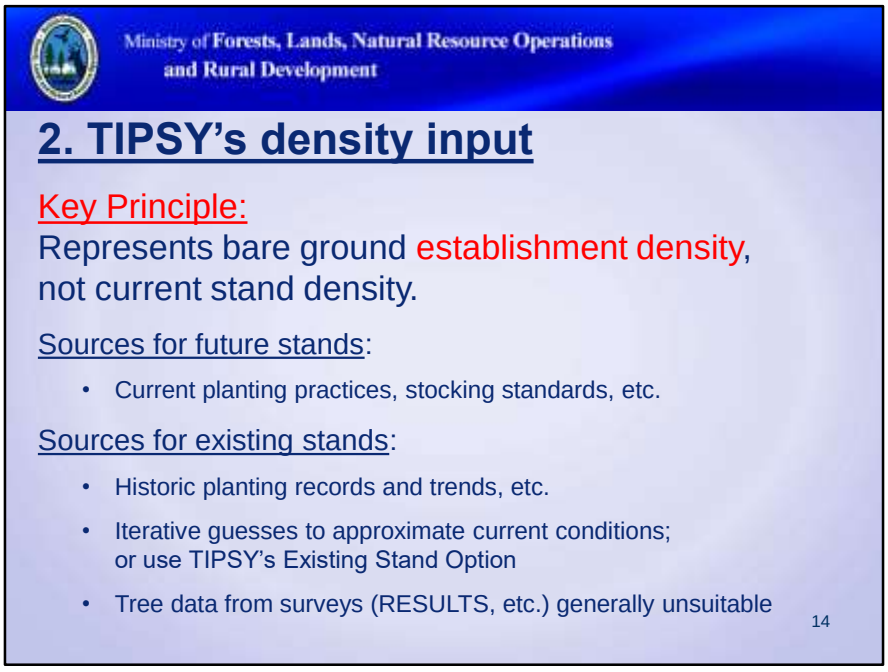
Natural (random): random spatial pattern, 5-9 years of establishment period

Clumped distribution is only available for natural-origin **Hwc, At, Fdi, Pli, and Sw**



For Planted, TIPSY assumes 1 yr-old seedlings and a 1 year establishment period.
For naturals (Random and Clumped), seedling establishment period is 5-9 years, depending on density.
In both cases, mortality and adjustment factors will affect tree counts from the beginning.

Regeneration **Delay** (yrs) is the number of years from disturbance (e.g. harvesting or fire) to the beginning of the stand establishment period.
The default **Delay** for natural regeneration (**Natural** or **Clumped**) is **2 yrs.** This default represents the average time lag until a good seed year.
For **Planted,** the default is **0 yrs.** This default assumes planting takes place the same year as the disturbance.



The strong desire to use tree counts from surveys is understandable, but TIPSY can only interpret them as establishment density.
Survey counts from plantations also include ingress, which TIPSY can't separate from planted stock, temporally, spatially, or genetically. TASS has that ability.

Well-spaced tree counts are used to assess stocking, but they make poor TASS-TIPSY inputs. TASS-TIPSY needs to model ALL the trees to accurately reflect inter-tree competition and crown dynamics. Total tree counts from early stocking surveys can sometimes be used with caution.

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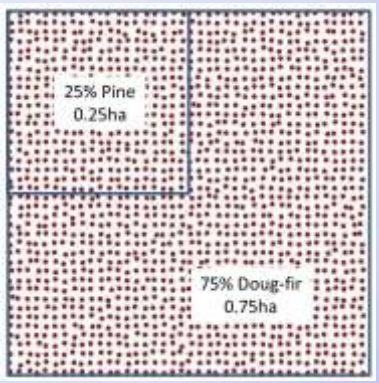
3. Multiple Species in TIPSY & VDYP

Both single-species models

- Fixed species composition; no species dynamics
- Stand yield = area-weighted average of single species yields

Example: per hectare yield for 75% Doug-fir, 25% pine = 0.75ha pure Doug-fir + 0.25ha pure pine



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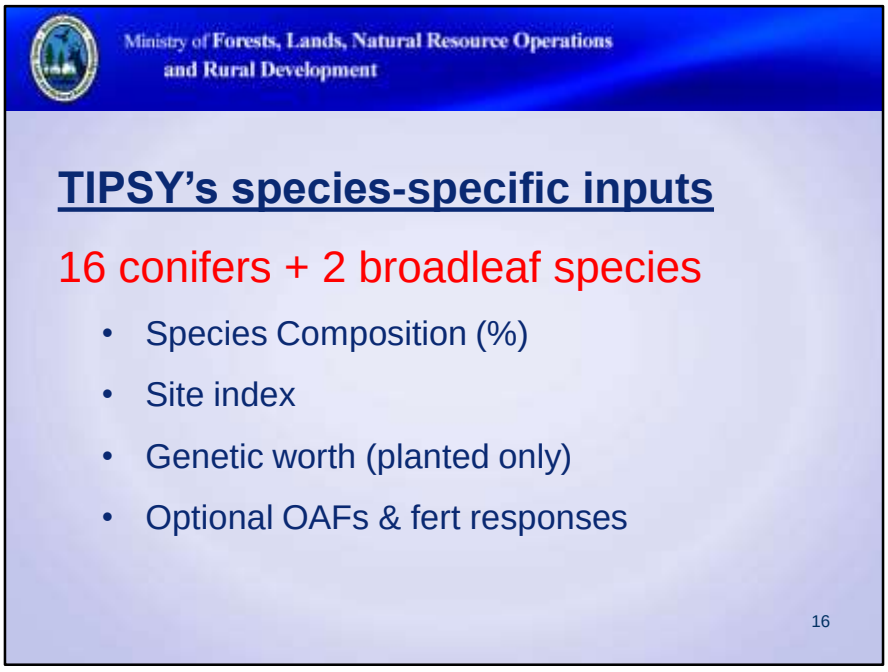
TIPSY and VDYP are both single species models. TASS-III handles multiple species.

Although not biological, this method is not too bad for species with similar growth rates. The Site index conversion adjustment is the only biological adjustment.

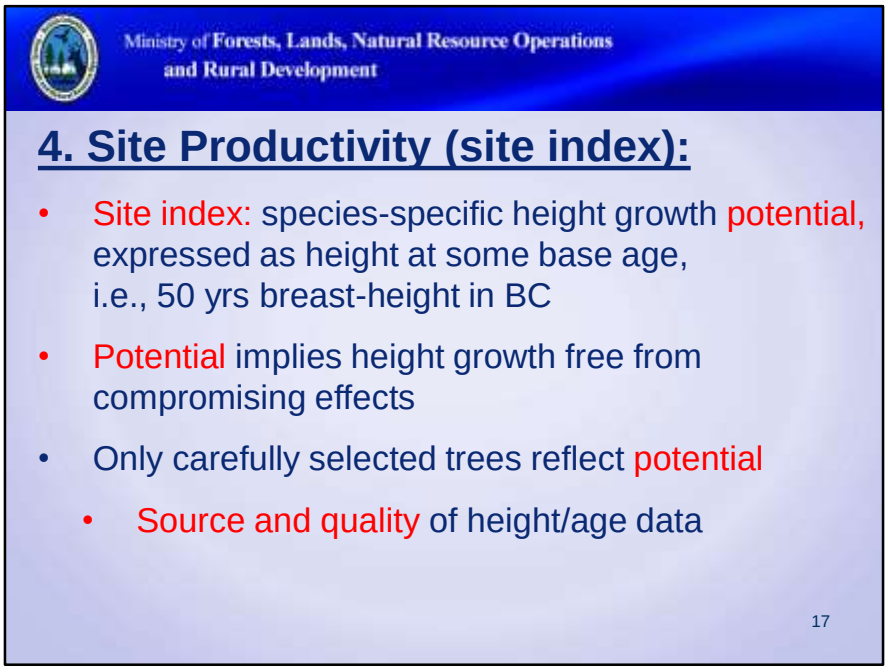
While the assumption is common in forest-level planning, be cautious making stand-level interpretations with it.



TIPSY covers 16 important commercial conifer species found in BC and 2 broadleaf species (red alder and aspen).

As noted before, site index has a big impact on yields, so use best available estimates.

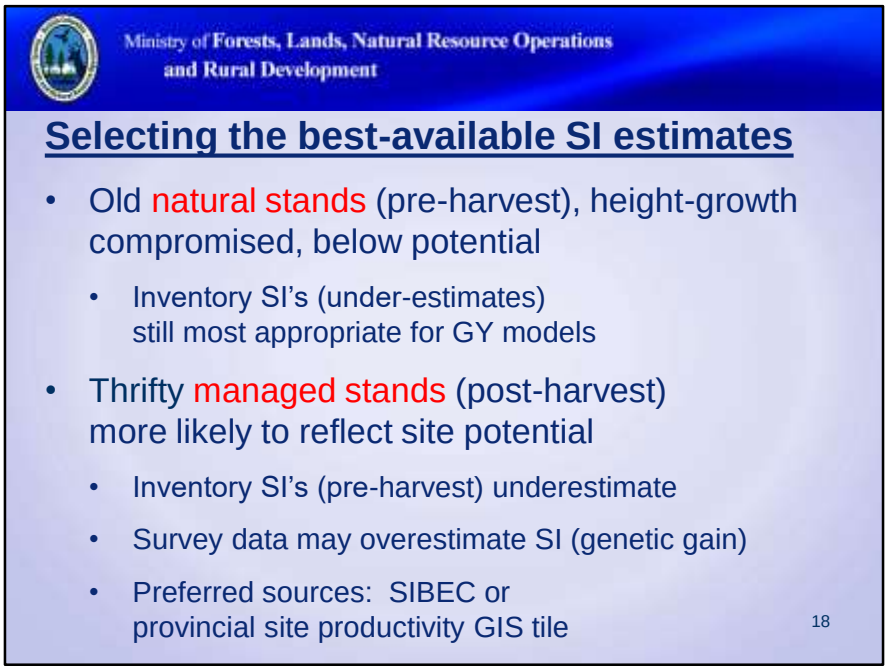
TASS-III was developed specifically to handle complex stands with multiple species and ages.



Site index is a common site productivity measure world wide, and the only one used in BC GY and inventory. However, **site index is often poorly understood and misapplied.**

Potential is the key concept here. Potential height growth provides a stable biological baseline for growth modelling.

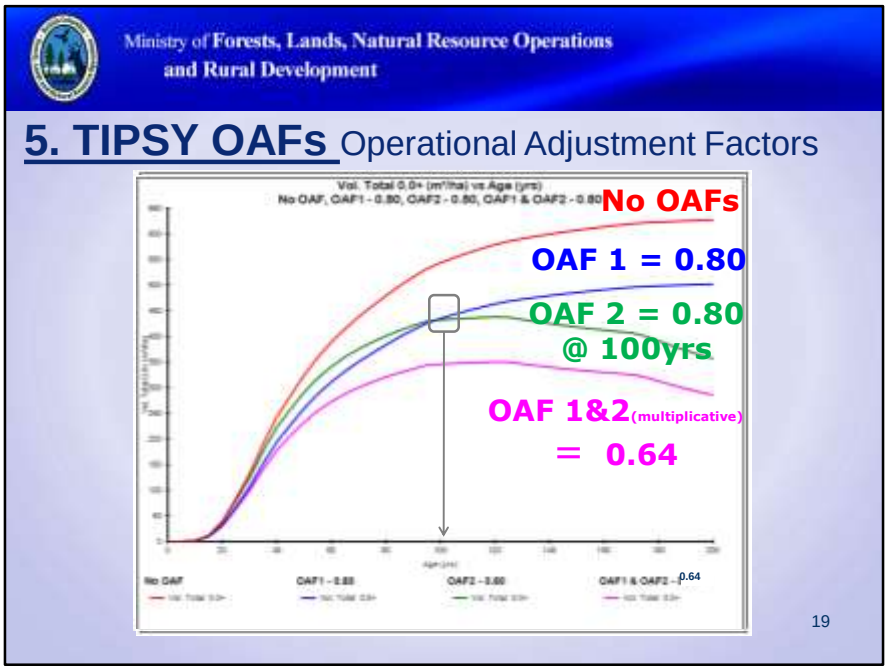
Without careful tree selection, height and age measurements can easily be confounded by historic stand conditions (e.g., suppression, forest health, management practices, etc).



Natural stands commonly accumulate negative impacts with age. Plus, their inventory SI's are derived from air-photo estimates of height and age.
Extensive old-growth studies in the 1990's documented these underestimates.

Field heights and SI's from surveys (RESULTS, etc) are often enhanced/confounded by genetic gain (tree improvement).
TASS-TIPSY also account for genetic gain, and their methods are more robust than SI alone.
Avoid double-counting and overestimation by using indirect methods like SIBEC (etc).

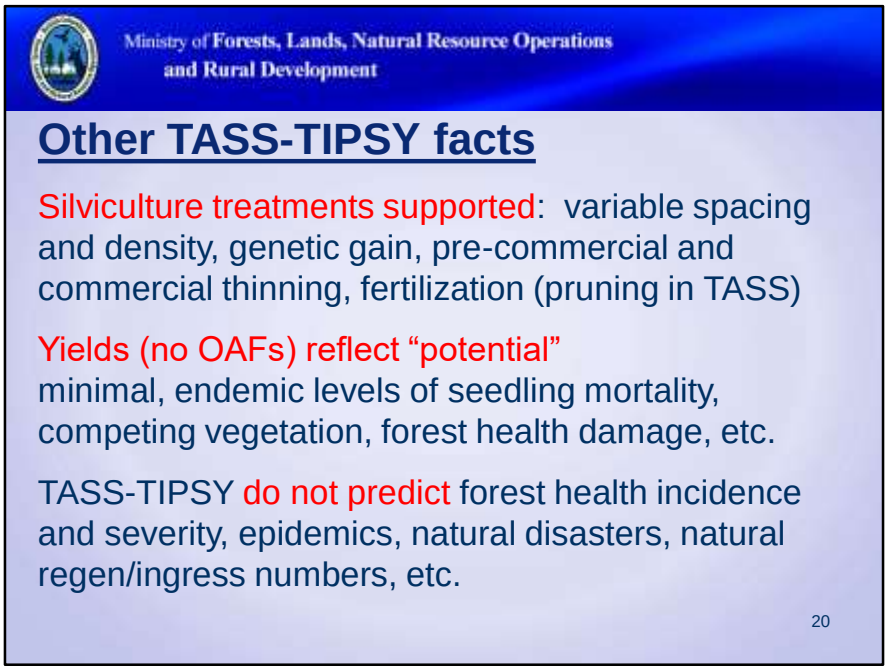
SIBEC refers to a provincial database containing SI estimates by BEC site series. BEC is BC's Biogeoclimatic Ecosystem Classification system.
Strict SIBEC sampling standards help ensure tree selection reflects potential.
The Provincial Site Productivity GIS tile includes the latest SIBEC estimates.



OAF1: non-productive areas (rock, swamp etc.)-constant multiplier
OAF2: loss factor (decay, waste, breakage etc.)-increasing multiplier
Standard default for TSR: OAF1=0.85 (15%) and OAF2=0.95 (5%)

Illustrates how OAFs interact and effect yield. No OAF vs OAF1 for .80 or 20%, OAF2 for .80 or 20%, and the combined multiplied effect of both OAFs of .64 or 36%

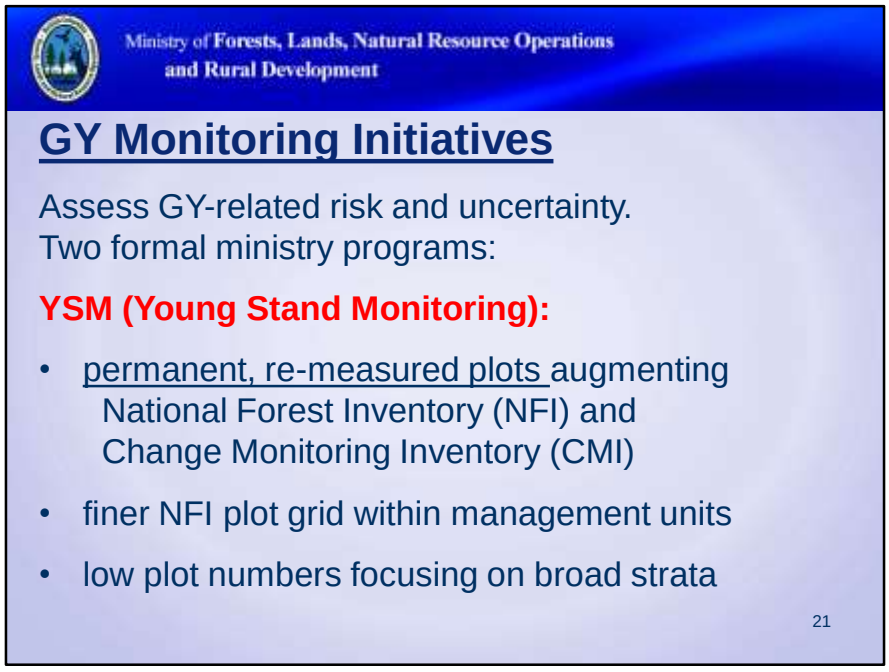
Note how OAF1 is a constant % reduction, while the OAF2 impact increases over time. OAF2 reaches it's assigned value (i.e., 20% here) at 100 years.



TASS's focus on crown dynamics makes it particularly suited to modelling response to silviculture, including many new and innovative practices.

Potential yields provide a more stable, consistent baseline for growth predictions than "average" yields. Potential yields focus on basic tree biology and are less dependent on stand history.

Modelling significant stand damage usually involves user manipulation of inputs (density, OAFs, etc) to approximate impacts visible today.



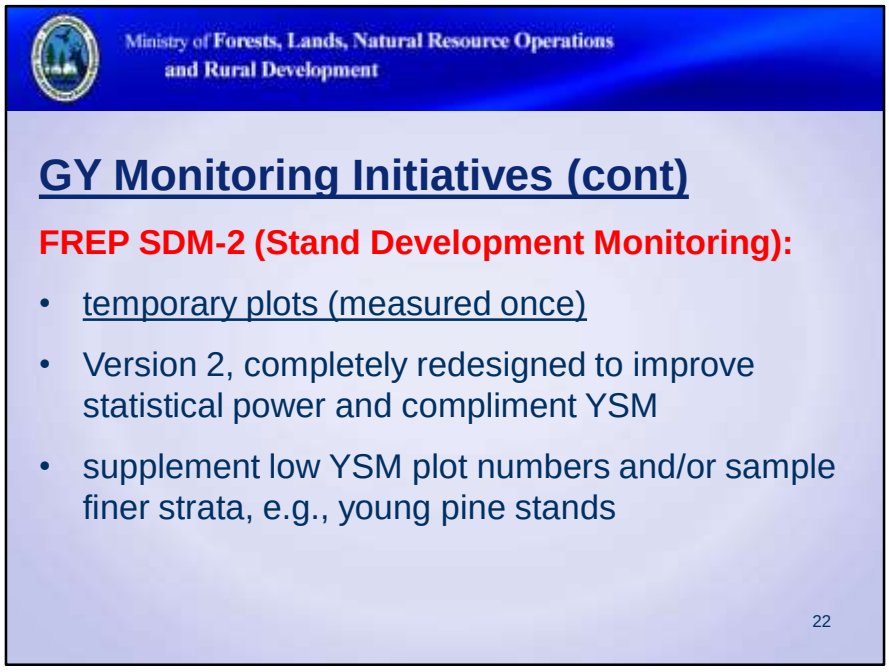
YSM is managed by Forest Analysis and Inventory Branch.

CMI (Change Monitoring Inventory) plots, originally established by licensees, have been incorporated into YSM.

Plot establishment on-going by management unit. Remeasurements have begun on the earliest installations.

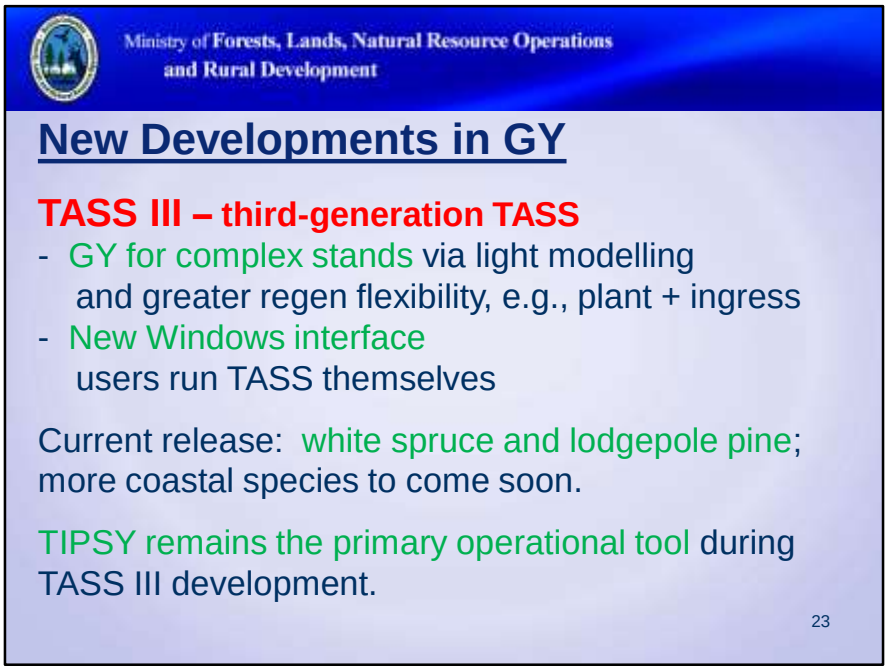
Low plot numbers (~30) per management unit reflect budget constrains, and limit assessments to broad strata, e.g., all young stand combined. Opportunities to evaluate finer strata are therefore limited.

General statistical rule-of-thumb: ~30 samples (plots) needed to evaluate any given population (strata or sub-strata).



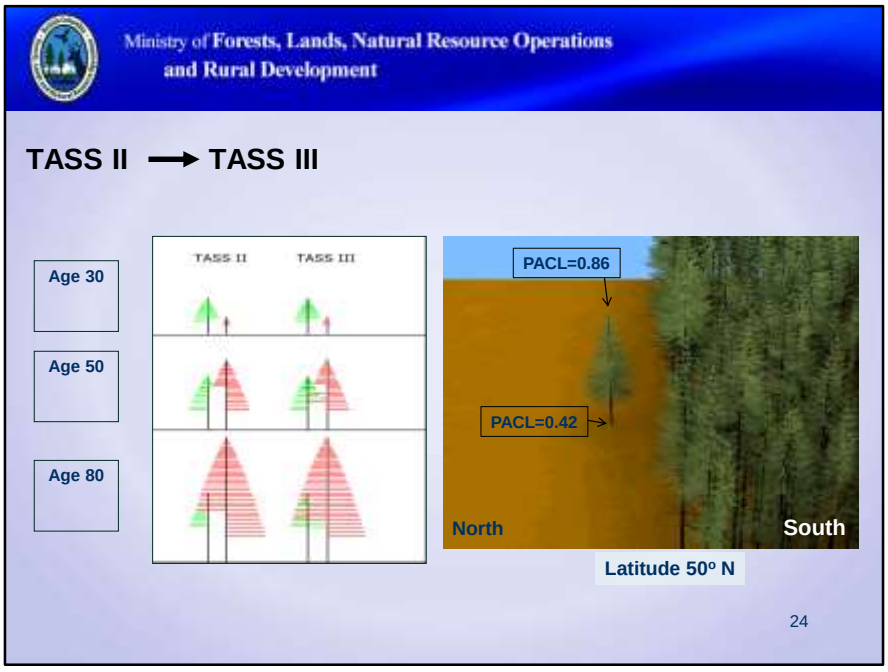
SDM is part of the FREP (Forest and Range Evaluation Program) managed by Resource Planning and Assessment Branch. SDM sampling is guided by district priorities.

Sampling costs for monitoring commonly restrict sample size and limit statistical comparisons to broad strata, regardless of management unit size.



GY of Complex stands (mixed-species and uneven-aged) via light modelling.

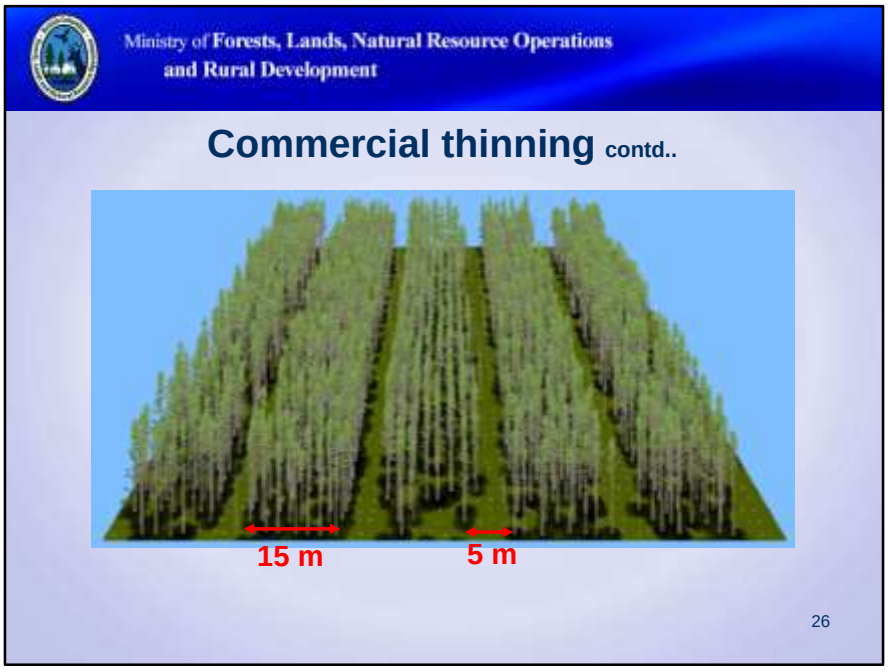
TASS III is the first version of TASS that can be run by practitioners themselves, through a new Windows interface. It provides a huge amount of flexibility for designing and comparing management regimes.



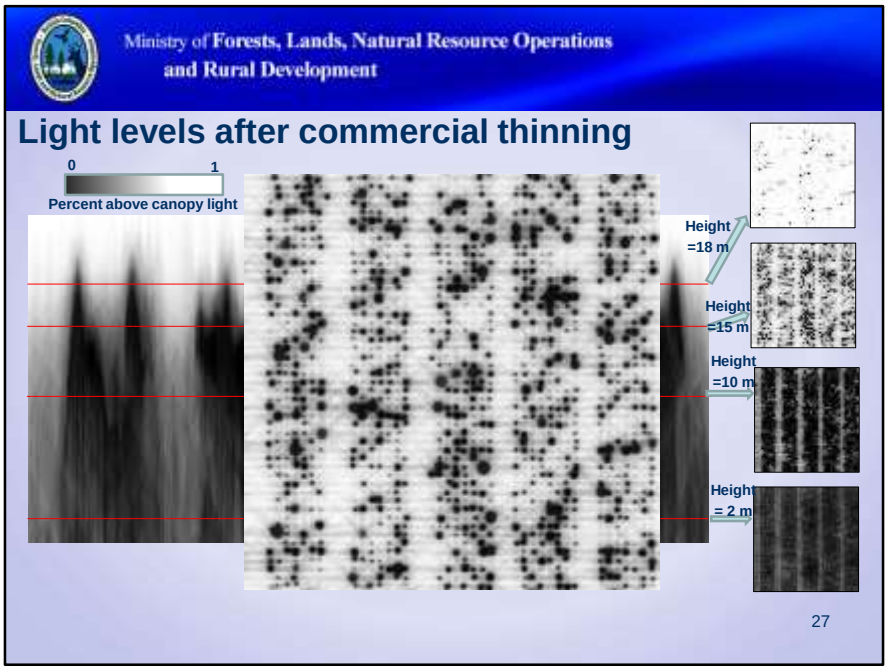
As well as some important changes in program architecture that permitted multiple canopy layers to be accommodated in the model, the introduction of a ray-tracing, hemispherical model (**tRAYci**, A. Brunner, 1998) for light dispersion is the most important development.

The light model predicts light levels on a scale relative to above canopy conditions or "percent above canopy light" (PACL)

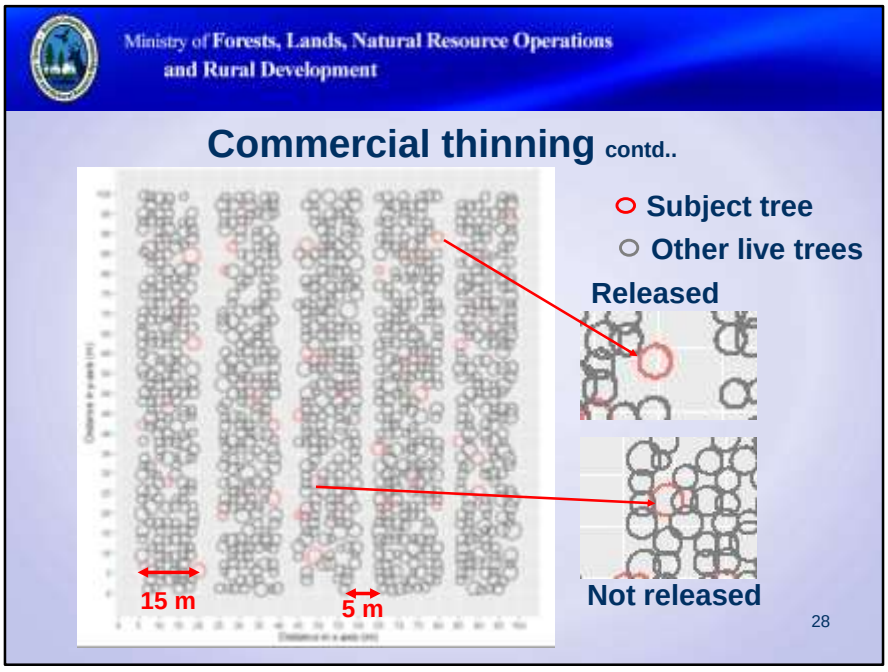
- These are the information required for simulating TASS III.
- The same stand was simulated with thinning treatment and without thinning (control)



- 3D view of the stand after thinning operation in TASS III.
- Thinning does not release all the trees in the residual stand
- TASS III, as a spatially explicit model, allows us to assess how each and every tree responds to the treatment



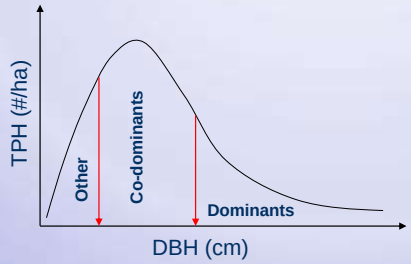
- The **tRAYci** light model (in TASS) allows us to assess light level at different heights around a tree in the stand
- Quantification of light reaching at different canopy layers can be linked to self-pruning of lower branches, natural ingress, forage availability….



- Two types of individual trees were selected as subject trees:
  - Trees that were released by thinning operation (two or more sides of crown release)
  - Trees that were not released by thinning
- All the subject trees were also assigned D=dominant, C=co-dominant and O= intermediate and suppressed crown classes

Defining crown class of the sample trees

Crown class	Mean DBH (cm)	Mean Height (m)
Dominant (D)	23.5	18.5
Co-dominant (C)	18.5	17.7
Other (O)	15.1	16.2



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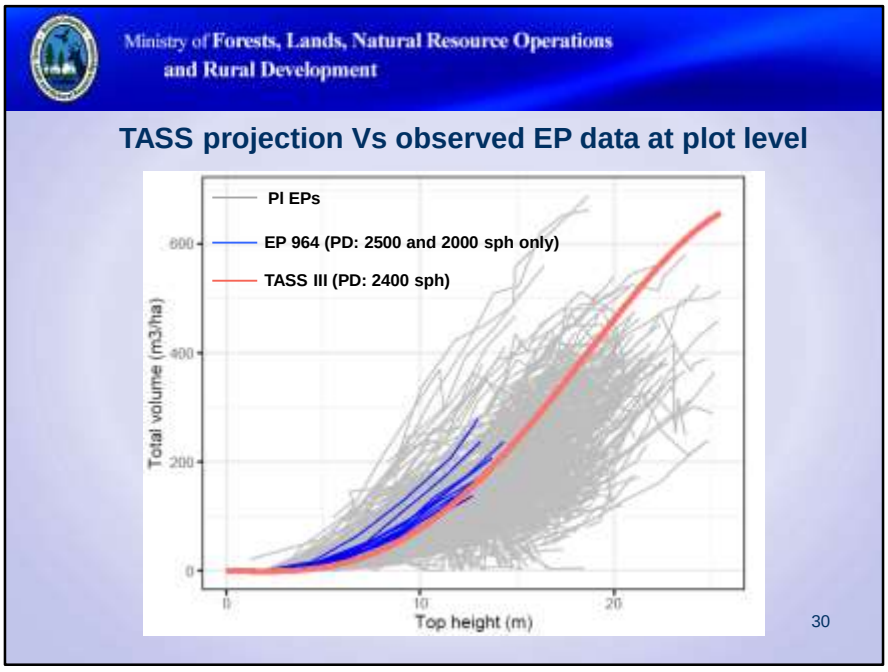

- The cloud of gray lines represent the observed range of total volume over top height
- Blue lines represent the development trajectory of plots that were planted with 2000 and 2500 stems/ha
- The red line represents the TASS simulated control plot (Pl, planted, 2400 sph, SI=20)

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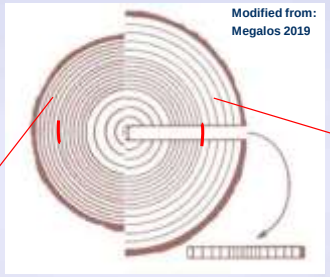
What's our expectation?



Response (or difference)= A tree attribute in thinned stand- the attribute of the same tree in control

Response (or difference)= 0 (no difference)

Expectation: At least the released trees show > 0 response

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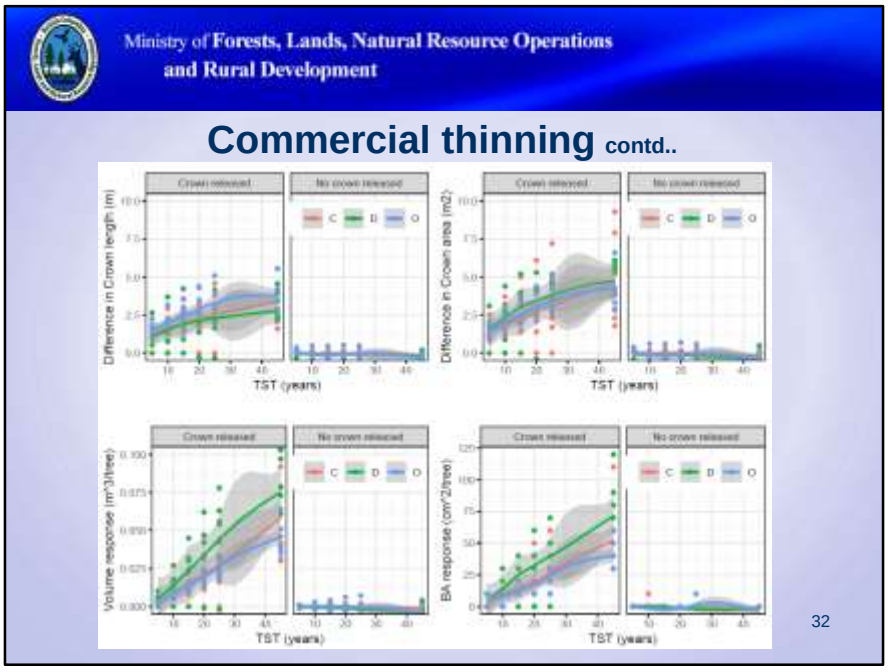
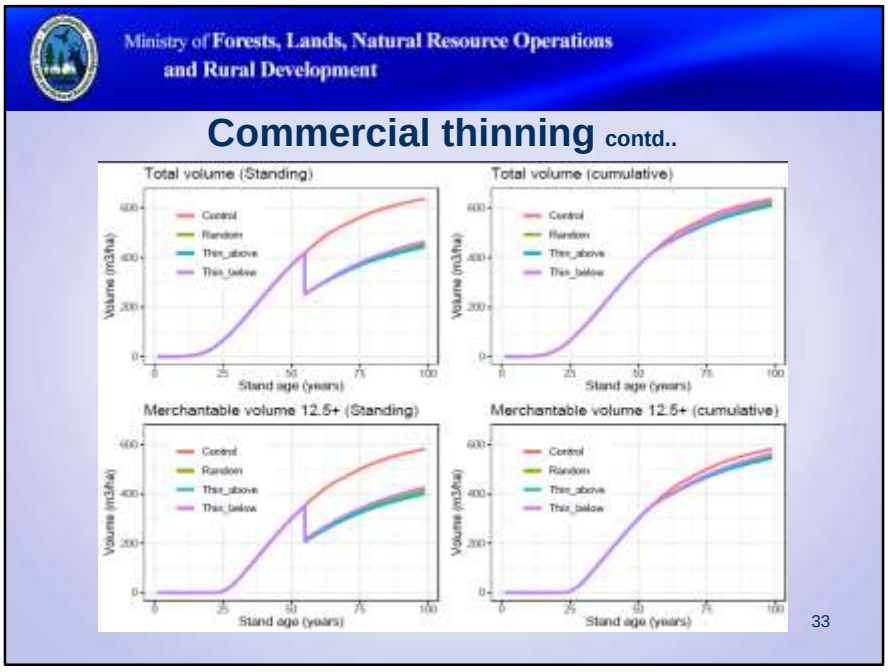
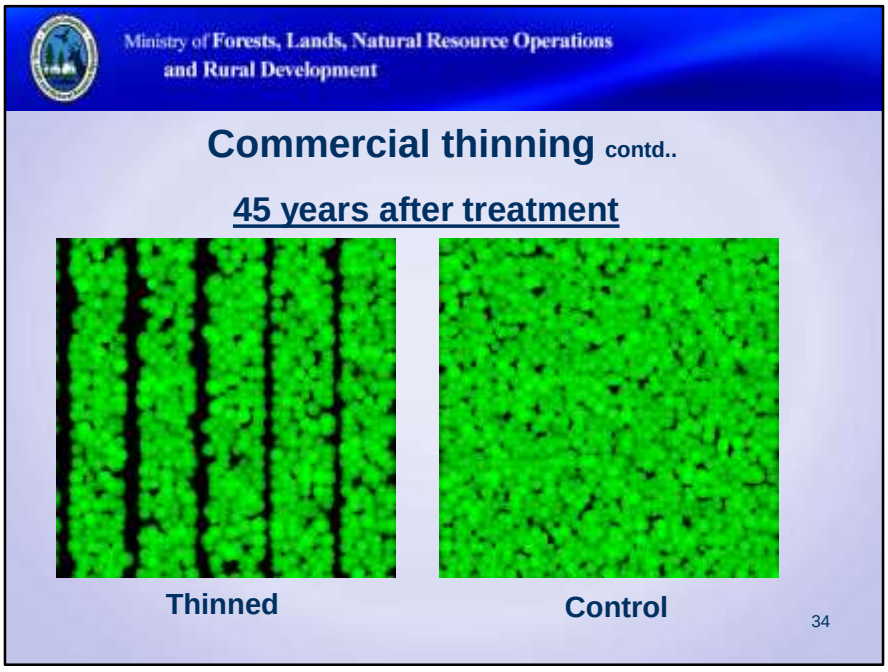
The beauty of computer models is that we can assess the growth performance of a tree in treated plot and in control simultaneously.
Tree attribute: crown area, crown length, individual tree basal area, stem volume of the tree



- For non-crown released trees: crown size (area and length), individual tree basal area and volume are same for thinned and control (response or diff=0)
- For released trees: (1) trees have wider and longer crown in the thinned stand than in control, and therefore (2) individual tree basal area and volume are much higher for trees in the thinned stand than in control.
- Among the crown released trees in the thinned stand, the response vary among trees of different crown classes at the time of thinning. Dominant trees showed the higher volume and basal area growth response than the trees of other crown class.



- Stand (combination of released and non-released trees) level response
- Thinned stand has fewer residual trees than in control
- Even if the released trees in the thinned stand grow more than in control, there are more trees to utilize site's growth potential in control. Therefore, the total yield is higher in control than in thinned stand.
- Thinning from below yielded the highest response and crown thinning yielded the least response among three different types of thinning.



- Optimal utilization of site's growth potential is the key to maximize stand yield.
- Please check the canopy gaps/holes in thinned and non-thinned stands

- Stand level models and other distance independent individual tree models cannot explicitly quantify these changes after a silviculture treatment.

Collaborative research is key to addressing the multi-disciplinary issues facing forestry today.

GY models have become important tools to help evaluate management practices and guide investments.

TASS, TIPSY, and other GY software are available for download from the Ministry GY website above.