VDYP7 Sensitivity Analysis

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AUGUST 2008

FINAL DRAFT

Executive Summary

The focus of this project was to perform a VDYP7 sensitivity analysis to explore the impact of changes to the primary input attributes on volume and other VDYP7 outputs. This project was also an important opportunity to document and illustrate specific model characteristics that users will need to be aware of to successfully run VDYP7.

The analysis revealed that there are several differences between the implementation of WINVDYP7 and VDYP7 Console that may produce different results from the two processes. These are primarily related to limitation of WINVDYP7 to accept input for: second species age and height information, and; crown closure and basal area/ha information simultaneously. There also appears to be a difference between these two implementations of VDYP7 with respect to computation of percent stockable area.

An important component of this report was the identification of a number of unique VDYP7 features that new users of VDYP7 should be familiar with. Some of these features are highlighted below.

- Whereas VDYP6 might produce zero volumes in a yield table, VDYP7 will simply not produce a volume at all (i.e. VDYP7 will produce blanks rather than zeros values). This occurs when certain minimum thresholds are not met (i.e. if the forest stand is simply too young/short/unproductive to produce volume at the specified utilization level). VDYP7 may also produce blanks in a yield table for reasons other than the volume being zero i.e. processing errors. In addition, just because VDYP7 does not produce a volume at reference year does NOT mean it will not produce a volume LATER (i.e. as the stand ages), if threshold conditions are eventually met.
- In its current implementation, even if volumes are not produced, VDYP7 will simply copy over the input (photo-interpreted) basal area/ha and trees/ha values and the associated QMD value and these values will appear in the yield table. As a result the values of BA, TPH and QMD may appear to be disconnected at the point in the yield table where VDYP7 begins estimating these attributes.
- VDYP7 includes a module called VDYP7Back which estimates yield information prior to the reference year for a polygon. However, it is difficult for the model to harmonize the yield curves produced in the back-grow mode with those produced by the usual forward projection mode. As a result, it is not uncommon to observe a “gullwing” feature when the estimated attributes (e.g. volume, BA, QMD) are plotted over time.
- Unlike in VDYP6, VDYP7 will provide a different yield trajectory for each starting point. As a consequence, projection from a year other than the reference year will produce a different result compared to the standard reference year projection.
- Polygons that are less than 30 years of age at the reference year are treated differently in VDYP7 compared with older polygons. Input height (i.e. height at reference year) is ignored for these polygons and VDYP7 estimates a height based on the age and the estimated site index. If an estimated site index is not provided, VDYP7 will use the input height and age which may produce unexpected and possibly unreasonable results.

- Stockability (also referred to as percent forest land) is an important driver of all per hectare yields (basal area, trees and volume) projected by VDYP7. Stockability is generally not input directly rather it is computed in the extended core module of VDYP7.

Based on the findings of the sensitivity analysis, the report made a number of recommendations for future implementation:

1. Modify or add input screens to WINVDYP7 so that results from WINVDYP7 can be more closely compared with results from VDYP7 Console.
2. Modify the VYDP7 Console input format requirements to accept data as a *single flat file*, in an industry standard format (e.g. dbf, MS Excel, MS Access, etc.), to make the data input process easier for users.
3. Investigate and document the details of the computation and application of stockability in VDYP7.
4. Include a message on null yield tables to indicate if a polygon failed to process through VDYP7.
5. Review the list of warning and information messages that are generated to look for ways of reducing the number of messages that are generated and/or to allow users to filter the messages that are produced.
6. Modify the current implementation of VDYP7 so that photo-interpreted values for BA and TPH are *not* copied into the yield table for ages where the polygon does not yet meet the minimum VDYP7 thresholds for volume estimation.
7. Users must be made aware of the limitations of VDYP7 operation in the back-grow mode. Yield table production for a polygon should begin at the reference year to avoid the need to invoke VDYP7BACK. It is further recommended that “mode” be added to each line of WINVDYP7 yield table output so that yields produced using VDYP7BACK are clearly indicated to the user.
8. Investigate VDYP7 behavioural differences in FIPSTART compared with VRISTART modes in an effort to explain the volume projection differences observed in the sensitivity analysis.
9. Investigate the implications of certain VDYP7 behaviours on the current VRI statistical adjustment procedures.
10. Expand the sensitivity analysis to examine other management units and/or issues (e.g. impact of SINDEX changes (VDYP6 vs. VDYP7) on volume; impact of loss factor changes (VDYP6 vs. VDYP7) on volume; unexpected high volume predictions in a management unit; unexpected low volume predictions in a management unit; etc.).
11. Maintain a log of issues and their resolution (or special model features) so that information on the behaviour and appropriate use of VDYP7 can be shared among users (e.g. on the Ministry’s website).

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1 Introduction and Background

VDYP7 represents a major shift in growth and yield prediction modeling in the province. The previous VDYP6 model had been in use for over two decades. Hence, as with anything new, VDYP7 faces a number of challenges regarding its understanding and acceptance.

The new model, VDYP7, is considerably more complex and sophisticated compared with VDYP6 and it will, undoubtedly, take some time for users to become familiar and feel comfortable with the new model. The work on this project was an opportunity to document and illustrate common issues and anomalies that may be encountered when running VDYP7, from the perspective of a user.

Although there has been considerable testing and documentation of VDYP7 there is still a lack of understanding among some users of many of the unique characteristics and behaviours of the model. The focus of this project was to perform a sensitivity analysis, which explored the impact of changes to the primary input attributes on volume and other VDYP7 outputs. However, this project also documented many specific model characteristics discovered along the way ("tricks and traps") that users will need to be aware of to successfully run VDYP7.

The complexity of VDYP7 and the number of factors that influence the results produced by the model created challenges for this analysis. In an attempt to isolate the effects on the model, factors were tested one at a time. Changes in up to 9 levels of each of 14 different input attributes were evaluated based on 6 different output attributes. For each of these scenarios, output trends were examined over time in yield tables produced from age 50 to 350 – over the course of the analysis, several thousand yield tables were produced.

This sensitivity analysis was carried out on a random set of 20 polygons from the Golden TSA, distributed among 4 age groups (at reference year), all with average site index values. ***Since this sensitivity analysis was restricted to a very small sample of polygons, caution must be exercised before generalizing or extrapolating these results.***

However, working with a small data set made it feasible to discern model trends and potential relationships. In some cases, patterns were obvious; but in many others, the results were unclear or inconclusive. In a number of cases, the sensitivity analysis highlighted important features of VDYP7 (some of which are summarized in Sections 2 and 3 of this document). More details on the trends and patterns that were observed in the 20 test polygons are provided in Section 4.

2 Differences between WINVDYP7 and VDYP7 Console

There are several differences between the implementation of WINVDYP7 and VDYP7 Console (limitations with WINVDYP7) that may produce different results from the two processes. It is important for users to be aware of these important differences and their implications if they are using WINVDYP7 for individual polygon yield estimation. Some of the major differences we encountered are highlighted below:

- WINVDYP7 does not accept second species height and ages. However, the availability of second species information in VDYP7 Console often affects the yields estimated by the model (see Appendix A for an example of the potential differences). In VDYP7 Console, second species information is used in the computation of Lorey height, which in turn impacts volume.

- WINVDYP7 only allows input of either a) crown closure % or b) basal area/ha & trees/ha whereas VDYP7 Console will take both these types of attributes (i.e. crown closure %, basal area/ha and trees/ha) and use them concurrently to produce its estimates. These attributes (crown closure and basal area, in particular) may have a significant impact on volume and hence, in using default values for one of these attributes, WINVDYP7 may not produce the same volume yields as VDYP7 Console.

- Stockability is an important attribute in the VDYP7 context and is used as a multiplier for all per hectare values estimated by the model. WINVDYP7 provides the user the option of either using a default value for % stockable or providing a "% stockable area" value in the Stand Density pane. In contrast, the % stockable area cannot be input directly in VDYP7 Console. Rather, this attribute is computed by an extended core module based on various information in the input files (including non-vegetation cover %, etc.). As a result, the final per hectare values from WINVDYP7 and VDYP7 Console may not be the same.

3 Running VDYP7 Console

The rest of this document refers to running VDYP7 Console, the interface which most closely corresponds with the old VDYP6 Batch. VDYP7 Console is run from a command line and uses csv files as input and produces two ascii files (one with yield tables and one with error messages) as output. Samples of the command line, input files and output files are provided in Appendix B.

VDYP7 Console is highly flexible and produces numerous new output options[1] not available in VDYP6. Many of the output options are controlled through numerous "switches" in the VDYP7 Console command line. ***As a result, it is highly recommended that users read the "Volume 3 - VDYP7 Console Interface Guide" prior to any attempts to run the model.***

In addition to a thorough understanding of the basic run parameters (outlined in *Volume 3 - VDYP7 Console Interface Guide*), there are a number of important VDYP7 Console features and/or idiosyncrasies that were discovered over the course of this analysis, that a user should be aware of. The sections below highlight several of these.

3.1 When does VDYP7 not produce values in a yield table?

Differences between VDYP6 and VDYP7 in terms of how the output is displayed sometimes causes issues for users. Where VDYP6 might produce zero volumes in a yield table, VDYP7 will simply not produce a volume at all. That is, VDYP7 will produce blanks rather than zeros values in the yield table. VDYP7 will not produce volumes (and hence will report only blanks) when certain minimum thresholds are not met (i.e. if the forest stand is simply too young/short/unproductive to produce volume at the specified utilization level). For example,

- Quadratic mean diameter (QMD) is less than 7.5cm
- Height is less than about 7.5m at age 80 years

However, VDYP7 may also produce blanks in a yield table for reasons *other* than the volume being zero. Many of the reasons for VDYP7 producing a blank in a yield table can be corrected (e.g. missing BEC). Hence, when a blank yield table is encountered, users should always check the error log (one of the VDYP7 output files) for clues as to the problem.

Three types of error messages may be produced (with potentially multiple messages per polygon and issue):

- "W" is a warning. Yield values will still be generated.
- "I" is for information. Yield values will still be generated.
- "E" is a fatal error. ***Yield values will not be generated and blanks will appear in the yield tables.*** Details as to the cause of the problem will usually be provided (unless it is a "core library error").

[1] The output format is standardized but there is more flexibility in the attributes that are output. For example: specific years or ages can be included in the yield table; utilizations can be specified by individual species (i.e. mixed utilization within a polygon is possible); additional attributes are output including QMD, site height, Lorey height, basal area/ha, trees/ha, 5 volumes and mode (which indicates reference year, backgrow, or forward projection).

Where an “E”-type error was generated, there is a non-volume related reason that caused VDYP7 to produce blank values in the yield tables. Without consulting the error log, it may not be possible to distinguish between a blank representing a zero volume and a blank representing a failure for VDYP7 to process the polygon due to an error.

Some of the potential non-volume related reasons for VDYP7 producing blank values in the yield tables include:

- No BEC provided
- Presence of a non-forest descriptor or non-productive code i.e. NC, NSR
- Total species composition not equal to 100%
- Two occurrences of the same species in the species composition list (i.e. if a second occurrence of the same species is encountered, the second one will be ignored and the related species percent will also be ignored). For example, the species composition PL 50 FD 30 PL 20 would be interpreted as PL 50 FD 30. As a result (since the total species percent would be less than 100%), VDYP7 would generate blank values in the yield table.

Note that just because VDYP7 does not produce a volume at reference year, it does NOT mean it will not produce a volume LATER (i.e. as the stand ages). If the volume thresholds are not met initially for younger stands, VDYP7 will continue to test whether these conditions can be met as the stand ages. However, if a polygon still has not managed to achieve the threshold levels by about age 80, VDYP7 will “give up” and blank values will be provided for all volumes in the yield table for such a polygon.

3.2 When does VDYP7 not project basal area/ha, trees/hectare and QMD as expected?

VDYP7 is also used for stand projection. For example, polygons may need to be projected to the current year (for operational inventory purposes) or to the year of ground sampling (for VRI statistical adjustment analysis). If a polygon does not meet the VDYP7 thresholds for producing a volume, ***blanks*** (not zeros) will be produced for volume and Lorey height.

However, in its current implementation, even if volumes are not produced, VDYP7 will simply copy over the input (photo-interpreted) basal area/ha and trees/ha values and the associated QMD value and these values will appear in the yield table. Once the polygon is able to achieve the VDYP7 threshold values and produce volumes, the basal area/ha (BA), trees/ha (TPH) and QMD values will be estimated by VDYP7 and output to the yield table. The values estimated by VDYP7 at this point “may bear little relationship to the supplied values on the inventory, particularly when the supplied values are inconsistent with the yield relationships predicted by VRISTART”[2]. As a result the values of BA, TPH and QMD may appear to be disconnected at the point in the yield table where VDYP7 begins estimating these attributes.

This is illustrated in the sample yield table below. Note that this polygon did not meet the threshold for VDYP7 volume estimation at age 30 hence blank values appear for Lorey height (L Hgt) and all of the volume attributes (e.g. Vws, Vcu, etc.). However, despite the fact that no

[2] Page 11, *Volume 3 – VDYP7Console Interface Guide. Version 2.0*. January 2008.

volume is produced, the current implementation of VDYP7 copies the input (photo-interpreted) values for BA and TPH into the yield table at this age, as well as the QMD (Dia) associated with these values. In this example, the polygon has met the VDYP7 thresholds for volume estimation by age 40 so both Lorey height and volumes now appear in the yield table at age 40. At this point, the values for BA, TPH and QMD that appear on the yield table are those estimated by VDYP7. In this example, we can see that the values for these attributes estimated by VDYP7 at age 40 do not appear to be consistent (logical) with the input values that appear at age 30.

Table 1: Example of unexpected values for BA, TPH and QMD.

vvvvvvvvvv Table Number: 13 District: Two Map Name: 083C002 Polygon: 166 Layer: 1

Year	Age	Stand Composition	D Hgt	L Hgt	Dia	TPH	BA	Vws	Vcu	Vd	Vdw	Vdwb	Mode
2007	30	FDI 40.0 SE 30.0 HW 10.0 BL 10.0 AT 10.0	7.34		6.0	350.00	1.0000						Frwd
2017	40	FDI 40.0 SE 30.0 HW 10.0 BL 10.0 AT 10.0	10.21	9.09	19.3	102.54	3.0092	12.4	10.4	10.1	10.1	9.8	Frwd
2027	50	FDI 40.0 SE 30.0 HW 10.0 BL 10.0 AT 10.0	12.75	10.98	20.3	259.99	8.4004	40.7	34.7	33.7	33.4	32.6	Frwd

Note that QMD will be reported regardless of utilization (i.e. the specified utilization limits apply only to volume, BA and TPH). For lines in the yield table where volume has not been produced by VDYP7 and the BA and TPH have been copied from the input values, the BA and TPH utilization will be equivalent to the input utilization, which is 7.5cm+ dbh.

There is another common situation where the BA, TPH and QMD values projected by VDYP7 may appear to be anomalous. This is related to the linkage between backward and forward projection operating modes of VDYP7. These are described further in Section 3.3 below.

3.3 "VDYP7Back" anomalies

VDYP7 includes a module called VDYP7Back which estimates yield information prior to the reference year for a polygon. However, it is difficult for the model to harmonize the yield curves produced in the back-grow mode with those produced by the usual forward projection mode. As a result, it is not uncommon to observe a "gullwing" feature when the estimated attributes are plotted over time (see Figure 1). The "gullwing" may be observed with volume as well as other attributes including basal area and QMD and the issue appears to be more prevalent with higher site index polygons.

Back-growing may be required where new photo-interpretation has occurred since VRI Phase II ground sampling (i.e. for VRI Statistical Adjustment development). In such cases, the year of ground sampling would be less than the new reference year for the polygon and VDYP7Back would be needed to project the polygon to the year of ground sampling. However, it has been recommended that using VDYP7Back be avoided if possible. For example, ***it is recommended that yield table production begin at the reference year so that there will be no need to invoke VDYP7Back***[3].

[3] This can be controlled by a VDYP7 Console command line parameter.

However, if back-growing is enabled, users must be aware of the potential "gullwing" issue. It is further recommended that the option to display the projection mode for each line of the yield table be selected[4] as a reminder to the user of when VDYP7Back has been applied.

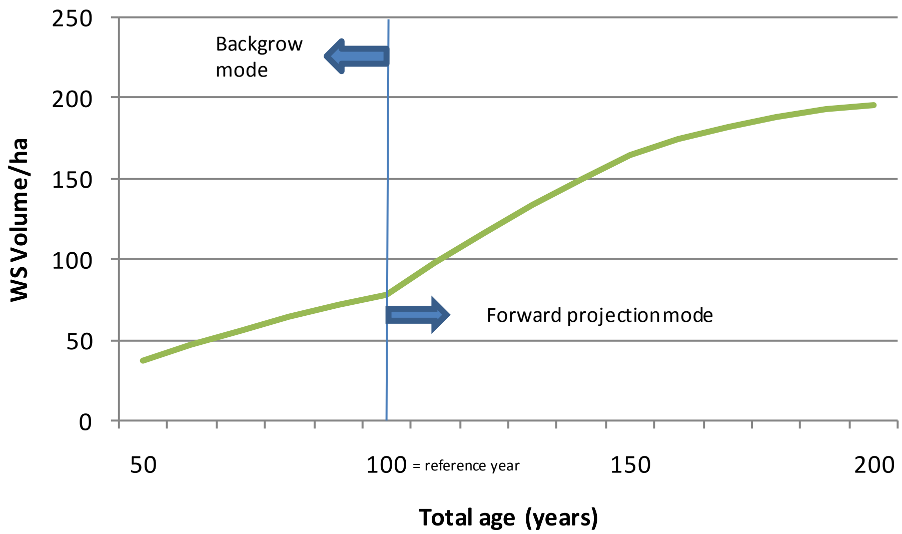


Figure 1: Example of the "gullwing" issue encountered when VDYP7Back is invoked. This data was taken from a sample yield table that appears on page 37 of the "Volume 2 – WinVDYP7 User Guide".

3.4 Projecting from reference year versus current year

Unlike in VDYP6, VDYP7 will provide a different yield trajectory for each starting point. As a consequence, projection from a year other than the reference year will produce a different result compared to the standard reference year projection. For this reason, ***users should never project volumes starting from already projected attributes. Projections should always begin from the reference year.***

In a VRI Statistical Adjustment, the reference year gets re-initialized to the year of ground sampling. Hence even in situations where the adjustment is minimal, some differences in projected volume over time can be expected simply because the starting point for the projection has changed.

This issue was examined using the 20 test polygons in the sensitivity analysis. Yield tables were produced from the reference year. Then the projected attributes from the yield table corresponding to the reference year plus 10 years were used as starting values for a new yield table (as if the polygon had been projected 10 years and the reference year reinitialized by adding 10). In about half of the test polygons, the difference in volume projected to age 200 was less than 2% but among the remaining test polygons, volume differences at age 200 as high as 9% were observed (see Figure 2). Interestingly, there was no apparent consistency in terms of which projection (i.e. from reference year or "current" year) resulted in higher volumes. However the reference year projection appeared more likely to produce higher yields than the "current" year projection for polygons that were a younger age at reference year.

[4] This is ensured by specifying the VDYP7 Console command line parameter: –includeprojmode Yes

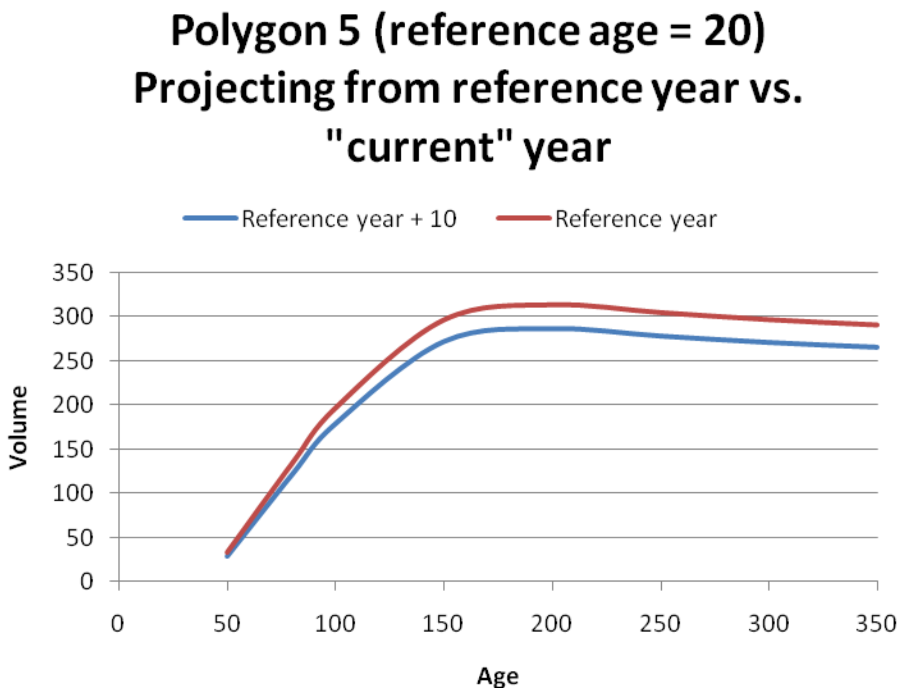


Figure 2: Example of volume yield curve differences when projecting from the reference year compared with the “current” year (assumed to be ten years after the reference year in this example).

3.5 Polygons with reference age <30 years

Polygons that are less than 30 years of age at the reference year are treated differently in VDYP7 compared with older polygons. Input height (i.e. height at reference year) is ignored for these polygons and VDYP7 estimates a height based on the age and the estimated site index. If an estimated site index is not provided, VDYP7 will use the input height and age which may produce unexpected and possibly unreasonable results.

Hence, it is critical that estimated site index (and estimated site index species) be provided for polygons with reference age <30 years!

Based on the results of the sensitivity analysis (see Section 4), VDYP7 appears to be insensitive to input basal area/ha and trees/ha when the reference age is less than 30 years. That is, these attributes appear to be ignored and the same yield curve will result regardless of the values of these attributes. However, for these same polygons (i.e. those less than 30 years of age at reference year) crown closure appears to influence volume. Initial analysis suggests that this may be related to the calculation of stockability but this cannot be confirmed at this point (see section 3.6 below).

3.6 Stockability in VDYP7

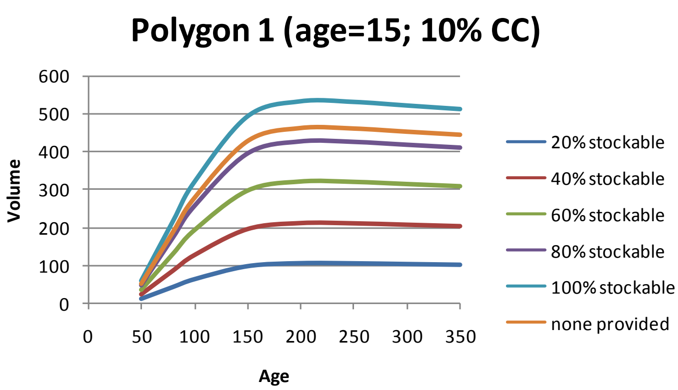
Stockability (also referred to as percent forest land) is an important driver of all per hectare yields (basal area, trees and volume) projected by VDYP7. Stockability is generally not input directly rather it is computed in the extended core module of VDYP7. This process is described in the *VDYP7 Console Interface Guide* as follows:

"If a stockability value is not supplied, it will be derived during VDYP7Console processing, as follows. The photo-interpreted crown closure is used to gauge what stocking level already exists, at the start of the projection. For VRI inventories, the additional area that may potentially fill-in over the course of a long-term projection is determined from the Shrub/Herb/Bryoid/Non-Veg cover percents. And how much of this additional area actually fills-in is further estimated from supplied age and disturbance information. For example, this additional area is assumed to fill-in more for polygons with younger stands than older stands; and for polygons with a recent disturbance.

For FIP inventories, the above cover percents have not been assessed and the additional area that may potentially fill-in must therefore be assumed. Age and disturbance information are employed, as above, to estimate how much of this area actually fills in." [5]

Among the input files, a field for PCT_STOCKABLE is available in the POLYGON.CSV file (note that there is no equivalent VRIMS field). When this input attribute was examined in the sensitivity analysis, it appeared to have a directly proportional impact on volume for polygons with reference age less than 30 years. However, for stands older than 30 years at reference age, there appeared to be no direct relationship with volume (even though no disturbance or non-veg/other-veg information was provided) suggesting that other attributes are being used to compute stockability even when it is provided directly. Examples for two polygons, one age 15 at reference year, the other age 220 at reference year, are shown in Figure 3.

It is strongly recommended that stockability and its computation in the extended core module, be further investigated and documented.



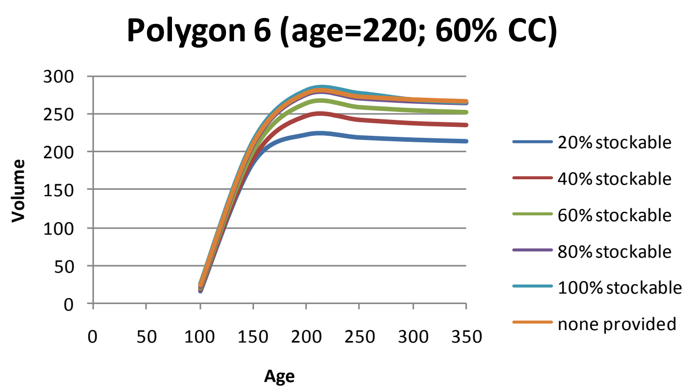


Figure 3: Example of volume yield curve differences for different values of input "stockability" for 2 sample polygons. Polygon 1 had an age of 15 at reference year and 10% crown closure whereas Polygon 6 had an age of 220 at reference year and 60% crown closure.

3.7 Non_veg, Other_veg, and History input csv files

The Non_Veg.csv, Other_Veg.csv and History.csv files are considered optional records for VDYP7 Console. If they are not provided, the non-vegetated and other-vegetated cover percents are assumed to be zero and the polygon is assumed to be undisturbed. Note that the non-vegetated and other-vegetated cover percents are not available for older FIP inventories (see section 3.6 for further details).

[5] Page 9, *Volume 3 – VDYP7Console Interface Guide. Version 2.0*. January 2008.

Although VDYP7 will run without these input files, ***this information can have a significant impact on projected volume hence it is important to include these types of files (if this data is available) when running VDYP7 Console***.

The non-vegetated and other-vegetated information appears to be part of the internal VDYP7 computation of stockability but the precise relationship could not be confirmed in this analysis. The presence of non-vegetative cover, for example, resulted in volume *reductions*[6] in younger stands that remained relatively constant over the projection period. For older mature stands, however, a volume reduction was not always observed or may have been quite small.

The history information provided to VDYP7 Console is used in a different manner. According to the *VDYP7 Console Interface Guide*[7], "this information is used to gauge what percentage of the polygon area will eventually fill-in over the course of a long-term projection. A recently disturbed area may be assumed to fill-in more quickly than if not disturbed." Among the small set of samples used for the sensitivity analysis, the presence of a history record (i.e. a disturbance code combined with a start year for the disturbance) resulted in volume *increases* in about half of the 20 polygons that were tested. These volume increases ranged between 3% and 34%. The nature of the relationship between disturbance information and resulting volume increases could not be discerned.

3.8 Impact of providing second species height

Second species heights and ages are available on VRI inventories but they are not provided for older FIP type inventories. Since the second species information impacts the computed Lorey heights, the availability of this data will affect the volumes estimated by VDYP7 (see Appendix A).

As a result, second species height and age, where it is available, should always be provided to VDYP7 Console.

However, it appears from the test set of 20 polygons used in the sensitivity analysis that second species height has a greater impact on Lorey height and volume for stands that are older (at least 120 years) at reference age (see Section 4.5).

3.9 Treatment of layers in VDYP7: polygons with vet layers

The current version of VDYP7 has been implemented with "layering lite"[8]. That is, apart from the primary layer, the veteran layer is the only other layer for which VDYP7 will produce yield table results.

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[6] Although the VDYP7Console Interface Guide suggests that this information is used to determine how much of the polygon is expected to fill-in over a longer projection (i.e. suggesting a potential increase in volume), we found that the presence of non-vegetative records often *reduced* volumes (and never increased) them among the 20 polygons we observed.

[7] Page 9, Volume 3 – VDYP7Console Interface Guide. Version 2.0. January 2008.

[8] Page 10, Volume 3 – VDYP7Console Interface Guide. Version 2.0. January 2008.

If a polygon has a veteran layer[9] (i.e. if a layer table is supplied as input to VDYP7), VDYP7 produces 2 separate yield tables for the polygon. It is then up to the user to aggregate the volumes from the 2 layers if they so wish.

The standard approach thus far has been to ignore the veteran layer. But if it is NOT ignored, the user must be sure to add the two separate yield tables that will be produced by ***merging on year (not age).*** ***If veteran layers are not ignored, users are strongly encouraged to check that the primary layer and veteran layer yield tables are not reported as separate polygons.***

3.10 Site index version difference between VDYP6 and VDYP7

Site height (or D Hgt on the yield table output) is projected using a call to SINDEX. Whereas VDYP7 uses SINDEX version 1.41 to project heights, VDYP6 height projection was done using SINDEX version 1.0[10].

A brief comparison of these two SINDEX versions revealed significant differences in the site curves for a number of species (see Appendix C for a comparison of site curves for selected species). For some species and site index combinations, height differences as high as 8m were observed at various points in the projection period. As a consequence, it is suspected that the change in SINDEX versions may be a major contributor to volume differences observed between VDYP6 and VDYP7 for some species.

[9] Note that in the unadjusted database for the Golden TSA, only 500 out of 28,000 polygons reported a veteran layer.
[10] The last update for VDYP6 that referenced SINDEX was in 1998 (part of the VDYP6 Version 6.6a). There were other updates of VDYP6, but there was no apparent reference to further changes to SINDEX in these subsequent versions. Hence it is assumed here that the last VDYP6 version used SINDEX 1.0.

4 Sensitivity analysis using Golden TSA data and basic input attributes

In an effort to further the understanding of the response of VDYP7 to changes in various attributes, a sensitivity analysis on basic input attributes was done for a small sample of polygons from the Golden TSA.

Since this analysis was restricted to 20 polygons from the Golden TSA, it is not appropriate to extrapolate the results. However, this analysis provides insights and greater understanding into the behaviour of VDYP7 and serves as a starting point for further analyses.

4.1 Approach

When dealing with province-wide or management unit-level data, there are many VDYP7 trends and behaviour patterns that cannot be distinguished. The focus of this sensitivity analysis was polygon-level response to changes in common input attributes. The approach was to take a very small number of polygons and look at individual VDYP7 output responses to one-at-a-time changes in input attributes.

Vegetated treed polygons within the Golden TSA were used as the base population of interest. This population was further restricted to polygons with "average" site index values[11]. That is, the test polygons were selected from those with site index values between 8 and 16. The VDYP7 response for polygons that had a very low or very high site index was not considered in this analysis.

These average site index polygons were then divided into 4 age groups, based on age at reference year:

- "Sapling" (<30 years of age)
- "Young" (30 to 79 years of age)
- "Younger Mature" (80 to 249 years of age)
- "Older Mature" (250+ years of age)

Five random polygons were then chosen from each of these 4 age groups.

All of the polygons were from "V"-type inventories. However, for some of the sensitivity runs, the test polygons were run through VDYP7 as "F"-type inventory records. For each sensitivity run (a single change to a single input attribute), a yield table from age 50 to 350 (in 50 year increments) was produced[12]. These yield tables formed the basis of comparison for the analysis.

Note that the change to the input attribute being tested was only applied at the reference year. Then a yield table was produced for polygon ages 50 through 300 at 50 year increments (with an additional output at 80 years). Graphs were produced from these yield tables, applying a

[11] The average SI for VT polygons greater than 30 years of age was 12, based on the INCOSADA files.

[12] An additional output was also produced for age 80 since VDYP7 appears to test if a polygon has achieved threshold levels of certain attributes (e.g. height) at this age.

smoothed line between the output points. Each graph of sensitivity analysis results in the appendices includes polygon age (at reference year) in the graph title. Hence it is possible to graphically estimate when the forward projection mode has been used in VDYP7 (any age greater than the polygon reference year) and when VDYP7Back has been invoked (any age less than the polygon reference year).

The anomalous dips and peaks apparent between the ages of 50 and about 100 years on some of the BA, QMD and TPH graphs are an artefact of how the model reports output when a polygon does not meet minimum QMD and/or height thresholds. With the current implementation of VDYP7, photo-interpreted input values (for BA and TPH[13]) are automatically copied over for output wherever the model is not able to produce a value (i.e. where the polygon does not yet meet minimum QMD and/or height thresholds). These photo-interpreted values may bear little resemblance to the first values of BA and TPH that VDYP7 produces hence producing the large dips and peaks on some of the graphs.

As the input attributes were changed, the resulting yield table changes in volume were the primary focus. However, the impacts on Lorey height, BA, QMD and TPH were also examined. The following sections highlight the results according to each input attribute that was changed.

Note that the following observations are specific and limited to the 20 test polygons from the Golden TSA examined in this analysis. Although some of the trends observed may indicate patterns in VDYP7 model behaviour, generalization of these observations is not recommended at this point.

4.2 Relative impact of changes in % crown closure on volume and other attributes

The impacts of changes in crown closure % on the 20 test polygons are illustrated in the graphs in Appendices E & F. Some of the trends observed are listed below:

- Similar impacts were observed for crown closures set at 80% and 100%.
- The biggest differences in projected BA and volume are seen when initial crown closure is less than 60%. That is, the impact of changing crown closure from 40% to 60% is more noticeable than changing crown closure from 60% to 80%.
- For polygons that are very young at reference age, a blank crown closure value appears to be interpreted as 0%. However, for stands older than about 50 years of age at reference year, it appears that a blank crown closure is interpreted as some non-zero default value.
- Initial differences in crown closure changes have the largest impact on future projected BA and TPH for stands that have a reference age of between about 30 and about 180 years. For polygons with a reference age greater than about 180 years, initial crown closure has very little impact on BA or TPH.
- Crown closure has no impact on Lorey height for polygons with reference age less than about120 years. However, for polygons with reference age greater than about 120 years, crown closure impacts Lorey height.
- Crown closure impact on volume appears to be related to crown closure impact on BA and Lorey height.

[13] QMD is computed directly from BA and TPH

4.3 Relative impact of changes in basal area/ha (BA) on volume and other attributes

The impacts of changes in basal area/ha (BA) on the 20 test polygons are illustrated in the graphs in Appendices G & H. Some of the trends observed are listed below:

- For polygons at the sapling stage at reference year, BA changes had no impact on QMD. This is most clearly seen for Polygons 3 & 4 where the QMD differences at 50 years projected age are related to different photo-interpreted (input) values for BA (i.e. at this point, the BA values are copied over from the input and are not model-derived). However, beginning at a projected age of about 80 years, VDYP7 begins computing a QMD which is the same for these polygons regardless of BA input.
- For very young polygons (less than 30 years reference age), BA has no impact on projected TPH except when the inventory standard is “F”. The projection of TPH is the same regardless of input BA if the polygon was from a “V”-type inventory. However, if the polygon was specified as an “F”-type inventory, TPH projection followed a much lower curve. This difference between and “F” and a “V” inventory was not observed for QMD in this age group.
- For the same group of polygons (sapling stage at reference year) BA changes have no impact on Lorey height.
- If a polygon is in a sapling stage at reference year, the impact of inventory type (i.e. “F” vs. “V”) on projected volume is highly significant. Input BA in a “V”-type inventory has no effect.
- For young polygons, those with reference age between ~30 and 80 years, the impact of BA changes begin to be seen for QMD and TPH. For these same polygons, BA impact on projected volume is quite distinct and directly related to initial BA (higher the BA, higher the volume).
- For polygons older than 80 years at reference age, the impact of changes to initial BA on projected QMD, TPH and volume is very direct and consistent.

4.4 Relative impact of changes in trees/ha (TPH) on volume and other attributes

The impacts of changes in trees/ha (TPH) on the 20 test polygons are illustrated in the graphs in Appendices I & J. Some of the trends observed are listed below:

- For stands less than 30 years, VDYP7 is insensitive to changes in TPH values (i.e. no impact on QMD, BA, Lorey height or volume).
- For age at reference year over 80, any change in TPH, so long as TPH remains less than about 1000 trees/ha, has only a minimal impact on volume. However, where TPH is higher than 1000 trees/ha, volume drops were observed.
- For older mature polygons (over 250 years at reference age), TPH values above 250 reduced Lorey height.

- If increased beyond some upper threshold (somewhere over 3000 trees/ha), TPH sometimes caused unusual and unexpected model behaviour with regard to BA and, in particular, volume.

4.5 Relative impact of changes in height on volume and other attributes

The impacts of changes in height (both first and second species height independently) on the 20 test polygons are illustrated in the graphs in Appendix K. Seven scenarios (i.e. combinations of first species height, HT1, and second species height, HT2) were tested:

1) HT1=HT2: HT1 is set to the same value as HT2 (note that a second species height was available for all 20 test polygons);
2) HT1=HT1+3m: initial value of HT1 was increased by 3m (HT2 was unchanged);
3) HT=HT1-3m: initial value of HT1 was decreased by 3m (HT2 was unchanged);
4) HT2= blank: value for HT2 was set to blank;
5) As input: initial values of HT1 and HT2 were unchanged;
6) HT2=HT1+3m: initial value of HT2 was increased by 3m (HT1 was unchanged);
7) HT2=HT1-3m: initial value of HT2 was decreased by 3m (HT1 was unchanged);

Some of the trends observed are listed below:

- Input height is ignored by VDYP7 for stands with reference age less than 30 years.
- For polygons with reference age between 30 and 80 years, changes in the second species height do not appear to affect Lorey height or volume.
- However, in this same age range (30-80 years at reference age), Lorey height and in turn, volume are both affected fairly directly by changes to the leading species height.
- The impact of changes to the second species height begins to be noticeable in polygons over 120 years at reference age and is more prominent in older polygons.
- Note that the impact of increasing BOTH leading species and second species heights simultaneously was not tested.

5 Recommendations

Based on the working knowledge and insights into VDYP7 gained in this analysis, the following list of recommendations is provided. Note that the numbering in this list does *not* indicate priority.

1. Modify or add input screens to WINVDYP7 so that results from WINVDYP7 can be more closely compared with results from VDYP7 Console:
   - include an input screen for second species information;
   - include an input screen for non-vegetative cover % and other attributes that impact stockability;
   - modify the input screen so that crown closure % as well as basal area and trees/ha can both be input for the same run.

2. Modify the VYDP7 Console input format requirements to accept data as a *single flat file*, in an industry standard format (e.g. dbf, MS Excel, MS Access, etc.), to make the data input process easier for users.

3. Investigate and document the details of the computation and application of stockability in VDYP7. In particular, examine the impact of non-vegetative cover, other vegetative cover and history information on stockability and how stockability may change with a projection.

4. Include a message on null yield tables to indicate if a polygon failed to process through VDYP7. Currently, VDYP7 may produce a blank (null) yield table due to non-volume related processing errors (e.g. total species composition not equal to 100%). Without examining the error log, this situation cannot be readily distinguished from a polygon that simply was not able to meet the minimum VDYP7 thresholds for QMD and height.

5. Review the list of warning and information messages that are generated to look for ways of reducing the number of messages that are generated and/or to allow users to filter the messages that are produced.

6. Modify the current implementation of VDYP7 so that photo-interpreted values for BA and TPH are *not* copied into the yield table for ages where the polygon does not yet meet the minimum VDYP7 thresholds for volume estimation. The current implementation often results in yield table inconsistencies for BA, TPH and QMD (which is calculated from BA and TPH).

7. Yield table production for a polygon should begin at the reference year to avoid the need to invoke VDYP7BACK (due to potential harmonization inconsistencies between the forward and back-grow modes of VDYP7). Where back-grow is required for special applications, it could still be invoked with a special command line parameter. However, users must be made aware of the limitations of VDYP7 operation in the back-grow mode. It is further recommended that “mode” be added to each line of WINVDYP7 yield table output so that yields produced using VDYP7BACK are clearly indicated to the user.

8. Investigate VDYP7 behavioural differences in FIPSTART compared with VRISTART modes in an effort to explain the volume projection differences observed in the sensitivity analysis. It is further recommended that the yield table output in VDYP7 Console be modified to indicate whether FIPSTART or VRISTART was used in the yield prediction.

9. Investigate the implications of certain VDYP7 behaviours on the current VRI statistical adjustment procedures (e.g. copying over photo-interpreted values when VDYP7 will not produce a value for BA and TPH; assuming zeros for blank values of attributes; adjustment of additional attributes such as Lorey height; etc.).

10. Expand the sensitivity analysis to examine other management units and/or issues (e.g. impact of SINDEX changes on volume; unexpected high volume predictions in a management unit; unexpected low volume predictions in a management unit; differences between VDYP6 and VDYP7 related to decay factors; etc.).

11. Maintain a log of issues and their resolution (or special model features) so that information on the behaviour and appropriate use of VDYP7 can be shared among users (e.g. on the Ministry's website).

Previous users of VDYP6 may not be aware that special issues/features such as those listed below can impact the volumes produced by VDYP7. The following items are recommended for inclusion in a VDYP7 issues/features log for users (as described in item #11 above). It is suggested that examples accompany each issue to clearly illustrate the potential volume impacts to the user.

1. Volumes should never be produced using initial attributes that have already been projected. Projections with VDYP7 should always start from the reference year, since, unlike VDYP6, the VDYP7 volume projection trajectory depends on the starting point (see Section 3.4 for details).

2. For polygons with reference age less than 30 years, estimated site index and estimated site index species must be provided, if available (see Section 3.5 for details).

3. Polygon input files for Non_veg, Other_veg and History information must be provided if available (see Section 3.7 for details).

4. Second species information (heights, ages) for a polygon should be provided, if available (see Section 3.8 for details).

5. If veteran layer information is provided to VDYP7, the model will produce two yield tables, one for each of the primary and veteran layers. To obtain total volumes for the polygon, it is up to the user to merge and add the layer volumes (see Section 3.9 for details).

6 Appendices

Appendix A: Impact of providing second species heights and ages (and crown closure)

Supporting Calc Library Version: 7.0i 25OCT04 BETA TESTING ONLY
VRIADJST Calc DLL Version: 1.02g
VDYPBACK Calc DLL Version: 1.02f
FIPSTART Calc DLL Version: 1.02g
VDYP7 Calc DLL Version: 1.02f
VRISTART Calc DLL Version: 1.02f
Calc DLL I/O Support Version: 1.01e
VDYP7 Low Level I/O DLL Version: 1.01j
Site Tools Version Number: 7.6a

Batch Parameters:
  Project Age Range:
    Start Age: N/A
    End Age: N/A
    Start Year: 2001
    End Year: 2007
    Increment: 1

  Reported Utilization Levels by SP0 Code:
    AC --> 12.5 cm+
    AT --> 12.5 cm+
    B --> 12.5 cm+
    C --> 12.5 cm+
    D --> 12.5 cm+
    E --> 12.5 cm+
    F --> 12.5 cm+
    H --> 12.5 cm+
    L --> 12.5 cm+
    MB --> 12.5 cm+
    PA --> 12.5 cm+
    PL --> 12.5 cm+
    PW --> 12.5 cm+
    PY --> 12.5 cm+
    S --> 12.5 cm+
    Y --> 12.5 cm+

Scenario 1: layer record which includes Crown closure of 55, and adjusted ages and heights for 2 species.

vvvvvvvvvv Table Number: 1 District: DKA Map Name: 092I088 Polygon: 463 Layer: 1

Year	Age	Stand Composition						D Hgt	L Hgt	Dia	TPH	BA	Vws	Vcu	Vd	Vdw	Vdwb	Mode
2001	131	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.49	20.86	36.6	387.74	40.8815	283.4	268.1	253.2	248.0	241.6	Ref
2002	132	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.58	20.96	36.8	386.10	40.9774	285.6	270.4	255.3	250.0	243.6	Frwd
2003	133	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.67	21.06	36.9	384.44	41.0687	287.8	272.5	257.2	251.9	245.5	Frwd
2004	134	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.76	21.16	37.0	382.84	41.1561	290.0	274.7	259.2	253.7	247.2	Frwd
2005	135	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.85	21.25	37.1	381.30	41.2394	292.2	276.8	261.0	255.5	249.0	Frwd
2006	136	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.93	21.35	37.2	379.78	41.3187	294.3	278.9	262.9	257.3	250.7	Frwd
2007	**137**	**FD 70.0**	**PL 20.0**	**AT 10.0**	**0.0**	**0.0**	**0.0**	**25.02**	**21.44**	**37.3**	**378.27**	**41.3939**	**296.3**	**280.9**	**264.7**	**259.0**	**252.4**	**Crnt**

^^^^^^^^^^ Table Number: 1

Scenario 2: no crown closure, but 2 ages and heights.

vvvvvvvvvv Table Number: 2 District: DKA Map Name: 092I088 Polygon: 463 Layer: 1

Year	Age	Stand Composition						D Hgt	L Hgt	Dia	TPH	BA	Vws	Vcu	Vd	Vdw	Vdwb	Mode
2001	131	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.49	18.21	36.6	387.71	40.8810	240.5	226.5	212.9	207.9	202.4	Ref
2002	132	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.58	18.30	36.7	384.80	40.7914	241.6	227.5	213.9	208.8	203.4	Frwd
2003	133	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.67	18.40	36.8	381.92	40.6975	242.6	228.5	214.8	209.7	204.2	Frwd
2004	134	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.76	18.49	36.9	379.07	40.5995	243.5	229.5	215.6	210.4	204.9	Frwd
2005	135	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.85	18.58	37.0	376.25	40.4977	244.4	230.4	216.4	211.2	205.7	Frwd
2006	136	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.93	18.67	37.1	373.45	40.3921	245.3	231.3	217.2	211.8	206.3	Frwd
2007	**137**	**FD 70.0**	**PL 20.0**	**AT 10.0**	**0.0**	**0.0**	**0.0**	**25.02**	**18.76**	**37.2**	**370.68**	**40.2830**	**246.1**	**232.2**	**217.9**	**212.5**	**207.0**	**Crnt**

^^^^^^^^^^ Table Number: 2

Scenario 3: no crown closure and only 1 age and height.

vvvvvvvvvv Table Number: 3 District: DKA Map Name: 092I088 Polygon: 463 Layer: 1

Year	Age	Stand Composition						D Hgt	L Hgt	Dia	TPH	BA	Vws	Vcu	Vd	Vdw	Vdwb	Mode
2001	131	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.49	19.38	37.1	377.64	40.8214	267.5	253.0	238.3	232.9	227.0	Ref
2002	132	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.58	19.45	37.2	375.04	40.7335	268.0	253.6	238.8	233.4	227.5	Frwd
2003	133	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.67	19.53	37.3	372.43	40.6413	268.5	254.1	239.1	233.7	227.8	Frwd
2004	134	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.76	19.60	37.4	369.78	40.5444	268.9	254.5	239.4	234.0	228.0	Frwd
2005	135	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.85	19.67	37.5	367.15	40.4437	269.2	254.9	239.7	234.2	228.2	Frwd
2006	136	FD 70.0	PL 20.0	AT 10.0	0.0	0.0	0.0	24.93	19.74	37.5	364.57	40.3392	269.6	255.3	240.0	234.4	228.4	Frwd
2007	**137**	**FD 70.0**	**PL 20.0**	**AT 10.0**	**0.0**	**0.0**	**0.0**	**25.02**	**19.81**	**37.6**	**361.99**	**40.2312**	**269.9**	**255.6**	**240.2**	**234.5**	**228.6**	**Crnt**

^^^^^^^^^^ Table Number: 3

VDYP7 Console Run Completed: 2007-Nov-11 14:39:18

Appendix B: Sample files for running VDYP7 Console

Polygon_id.csv

polygon_rcrd_id	maintainer	map_id	map_quad	map_sub_quad	polygon_ID
1	DCO	082K099	0	0	22
2	DCO	082K099	0	0	62
3	DCO	082K099	0	0	64
4	DCO	082K099	0	0	67
5	DCO	082K099	0	0	70

Maintainer = district

For all the subsequent tables, the unique POLYGON_RCRD_ID is used to reference the unique district map polygon

Polygon.csv

polygon_rcrd_id	inventory_standard	reference_year	fiz	bec_zone	pct_stockable	non_prod_desc	yield_factor
1	V	1996		ESSF			
2	V	1996		ESSF			
3	V	1996		ESSF			
4	V	1996		ESSF			
5	V	1996		ESSF			

Fiz is not used, and therefore not completed

If a non productive descriptor was available - ie AF, then it would be in this field

Layer_id.csv

layer_rcrd_id	polygon_rcrd_id	layer_id	vdyp7_layer_id	rank_code	non_forest_desc	meas_util_level	cc	ba	tph	est_si_spcs	est_si
1	1	1		1		7.5	30	2	725		
2	2	1		1		7.5	60	45	525		
3	3	1		1		7.5	50	50	425		
4	4	1		1		7.5	25	1	475		
5	5	1		1		7.5	50	45	525		

Note: vdyp7_layer_id is left blank

If a vet layer were present, it would be rank code 2.

cc = crown closure

If the polygon is < 30 then est_si_spcs and est_si MUST be completed

Species.csv

species_ rcrd_id	layer_ rcrd_id	species_ id	species_c d	species_ pct	age	height	si	ytbh	bhage	site_ curve	polygon_ rcrd_id
1	1	1	BL	100	35	6					1
2	2	1	SE	90	230	26					2
3	2	2	BL	10	230	26					2
4	3	1	SE	80	230	31					3
5	3	2	BL	20	230	28					3
6	4	1	BL	100	50	6					4
7	5	1	BL	50	220	22					5
8	5	2	SE	30	240	24					5
9	5	3	PA	20	60	10					5

species rcrd_id must be unique
Layer_rcrd_id must be unique and correspond to a record in the layer_id.csv file

History.csv

HISTORY_R CRD_ID	LAYER_ RCRD_ID	HISTORY_I D	SILV_ BASE_CD	START_ YEAR	END_ YEAR	LAYER_ PCT

If history were present, then layer_rcrd_id would be the link between the files.

non_veg.csv

polygon_ rcrd_id	NON_VEG_ID	NON_VEG_ COVER_TYPE	NON_VEG_ COVER_PCT

other_veg.csv

polygon_ rcrd_id	other_veg_id	land_cover_cd	land_cover_pct
1	1	TC	100
2	1	TC	100
3	1	TC	100
4	1	TC	100
5	1	TC	100

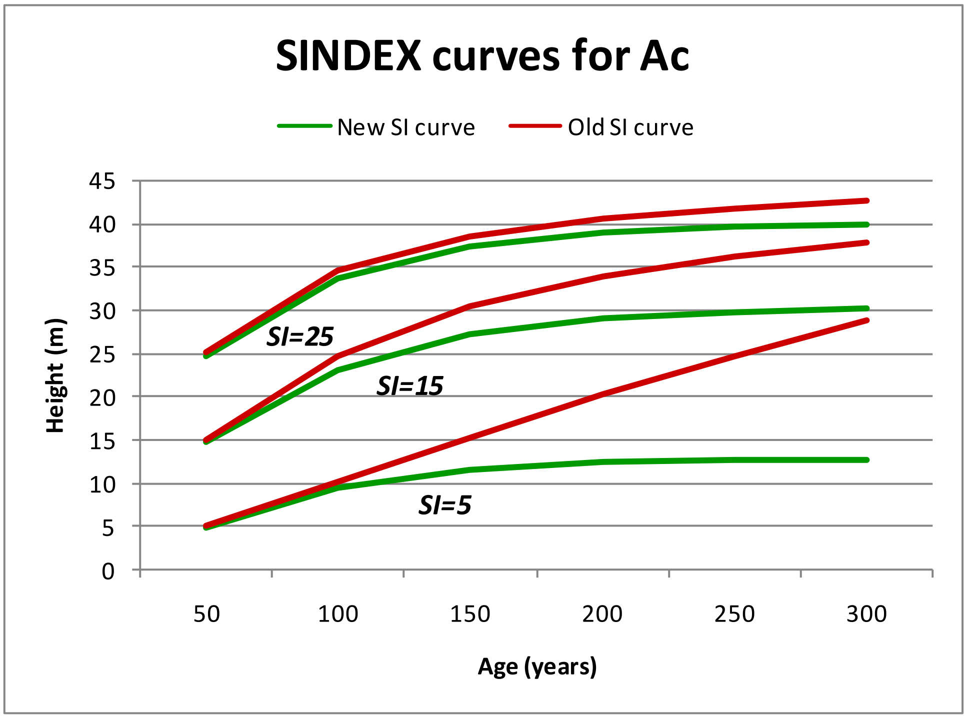
Other Veg_id must be unique with polygon_rcrd_id.

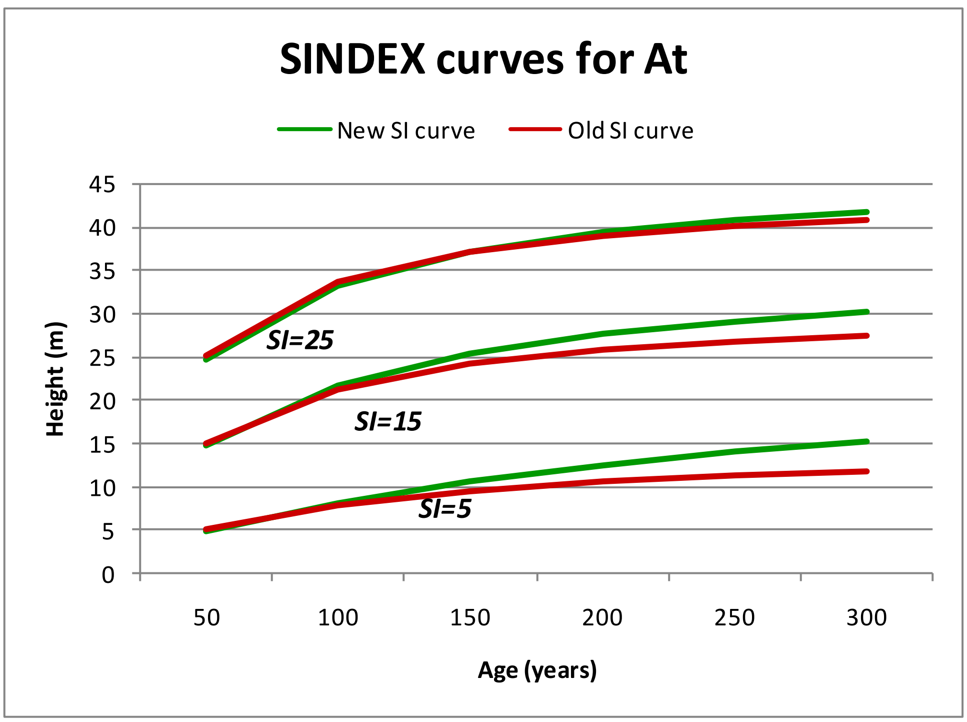
vriadjst.csv

vriadjst_rcrd_id	polygon_rcrd_id	layer_id	lh_075	ba_125	wsv_075	wsv_125	vcu_125	vd_125	vdw_125
1	6	1	6.7	8.1762	72.8422	31.0764	24.134	23.803	23.142
2	7	1	16.6	44.51	384.598	355.0644	314.51	297.65	292.03
4	9	1	16.6	44.51	384.598	355.0644	314.51	297.65	292.03
5	10	1	15.9	28.881	188.294	180.7661	160.53	153.38	150.56

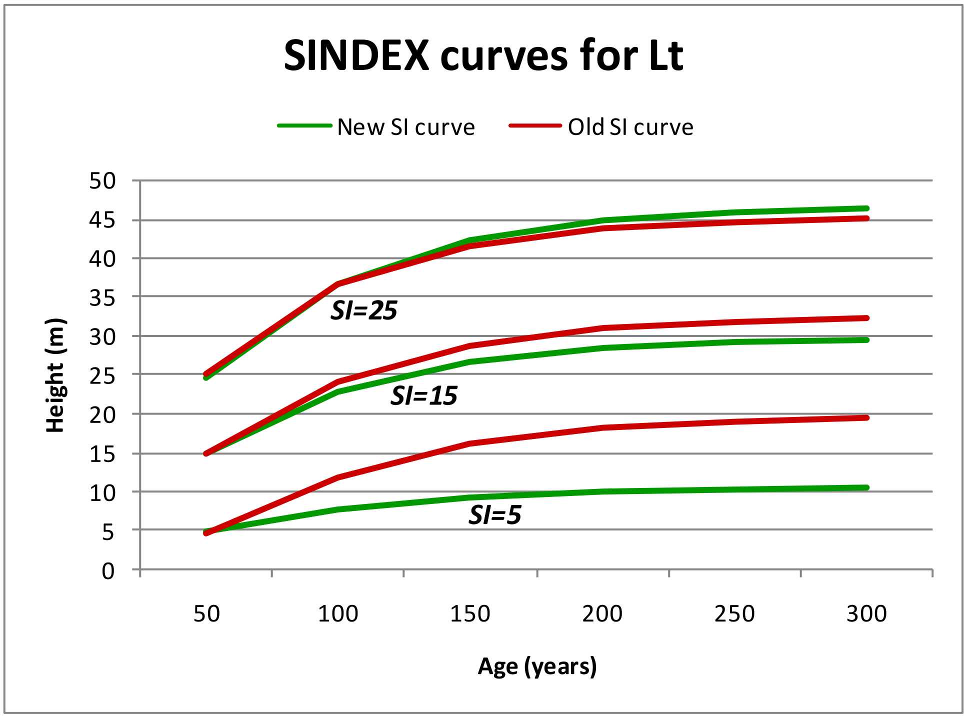
If there is an adjustment, then the starting values for lory ht (7.5), ba 12.5, etc must be provided in this format.
IF a polygon did not complete then it should be removed from the table.
vriadjst does not need to correspond to polygon_rcrd_id, but it may make it easier

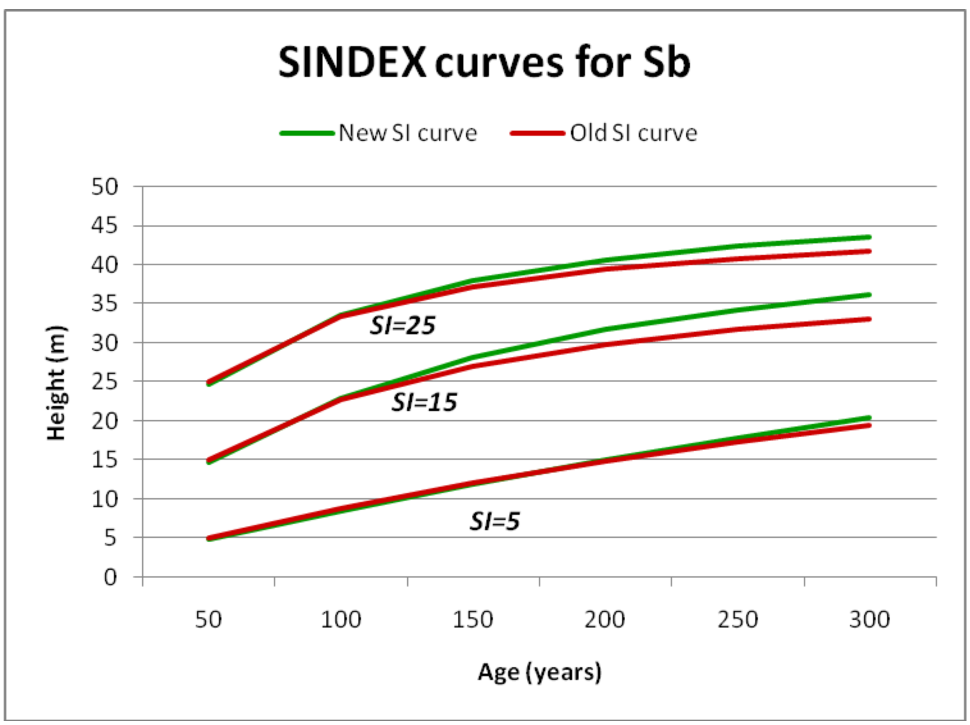
Appendix C: SINDEX 1.0 (old) versus SINDEX 1.41 (new) differences for selected species



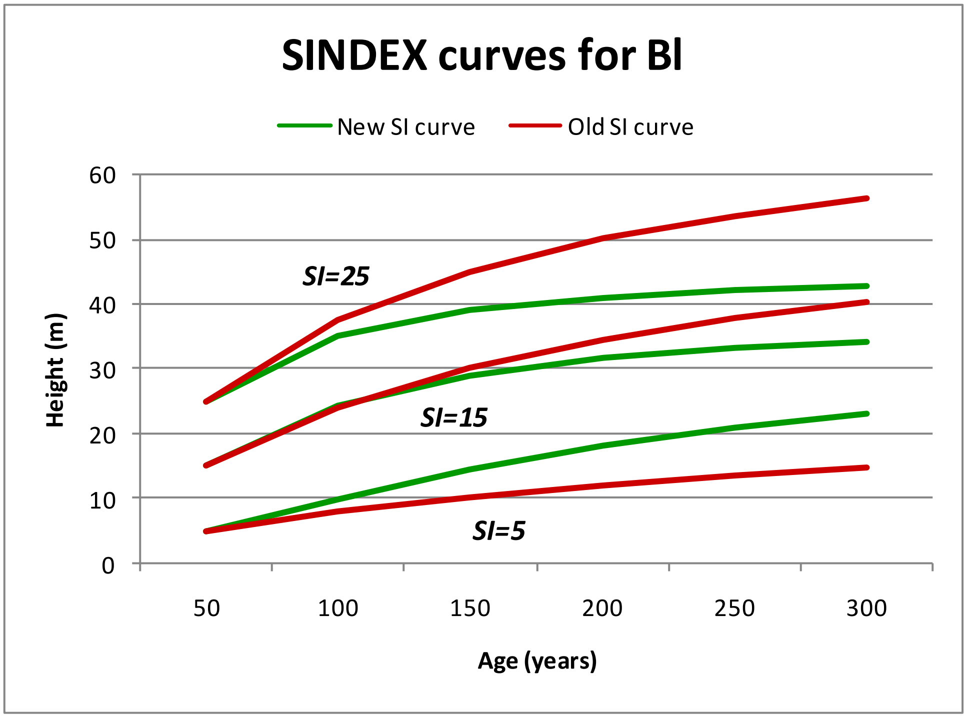


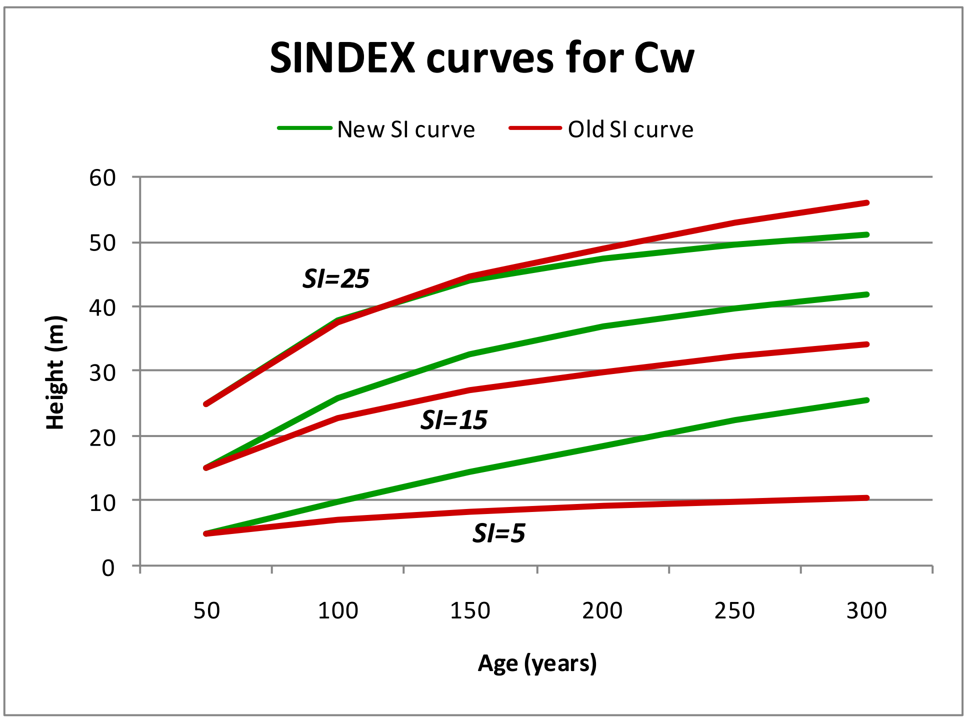
SINDEX 1.0 (old) versus SINDEX 1.41 (new) differences for selected species





SINDEX 1.0 (old) versus SINDEX 1.41 (new) differences for selected species



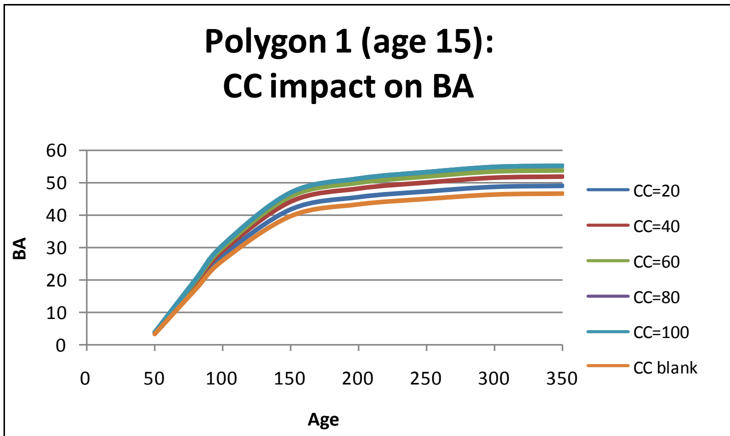


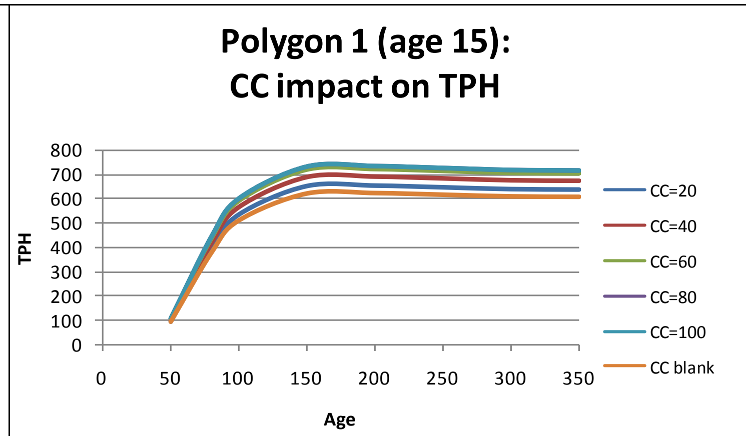
Appendix D: Original attributes for test polygons

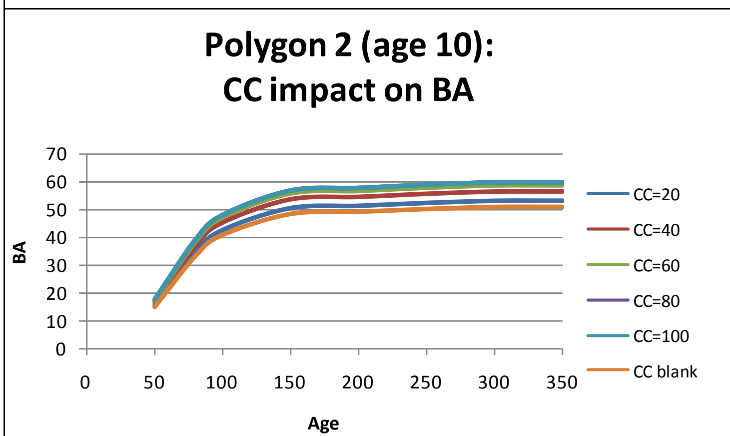
Polygon #	*Phase I BA*	*Phase I TPH*	*SP1*	*SP1 %*	*SP2*	*SP2 %*	*SP3*	*SP3 %*	*SP4*	*SP4 %*	*SP5*	*SP5 %*	*SP6*	*SP6 %*	*BEC*	*CC%*	*AGE_1 (@ref yr)*	*HT_1 (@ ref yr)*	*AGE_2 (@ ref yr)*	*HT_2 (@ ref yr)*	*REF YEAR*
1	0	450	FDI	50	CW	30	SE	20		0		0		0	ICH	10	15	3	15	3	1997
2	5	1400	AT	90	FDI	5	SE	5		0		0		0	ICH	60	10	5	23	7	1997
3	0	700	SE	40	FDI	30	PLI	20	CW	10		0		0	ICH	25	20	3	20	3	1997
4	10	1100	SE	80	FDI	10	HW	10		0		0		0	ICH	55	20	7	20	6	1997
5	1	350	FDI	40	SE	30	HW	10	BL	10	AT	10		0	ICH	15	20	5	20	5	1997
6	45	600	BL	70	SE	30		0		0		0		0	ESSF	60	220	21	240	27	1997
7	40	500	SE	60	BL	40		0		0		0		0	ESSF	55	140	24	130	20	1996
8	15	380	PA	60	SE	20	BL	20		0		0		0	ESSF	35	120	18	120	20	1997
9	40	575	BL	80	SE	15	PA	5		0		0		0	ESSF	50	180	20	220	26	1997
10	40	325	SE	65	BL	35		0		0		0		0	ESSF	45	240	32	220	29	1997
11	60	400	SE	70	BL	30		0		0		0		0	ESSF	60	260	36	240	30	1996
12	40	325	SE	60	BL	40		0		0		0		0	ESSF	45	260	32	240	28	1997
13	40	300	SE	80	BL	20		0		0		0		0	ESSF	40	280	34	240	28	1997
14	50	475	SE	60	BL	40		0		0		0		0	ESSF	60	280	31	240	26	1997
15	60	425	HW	60	SE	25	CW	15		0		0		0	ESSF	55	260	32	240	34	1997
16	10	850	BL	90	SE	10		0		0		0		0	ESSF	40	50	8	50	8	1996
17	30	800	SE	50	BL	30	FDI	10	PLI	10		0		0	ESSF	65	70	16	70	14	1996
18	20	550	BL	65	SE	35		0		0		0		0	ESSF	35	70	13	90	16	1997
19	5	400	AT	70	W	10	FDI	10	SE	10		0		0	ICH	20	40	9	40	7	1997
20	10	550	SE	50	FDI	30	BL	15	PA	5		0		0	ESSF	35	60	13	60	14	1997

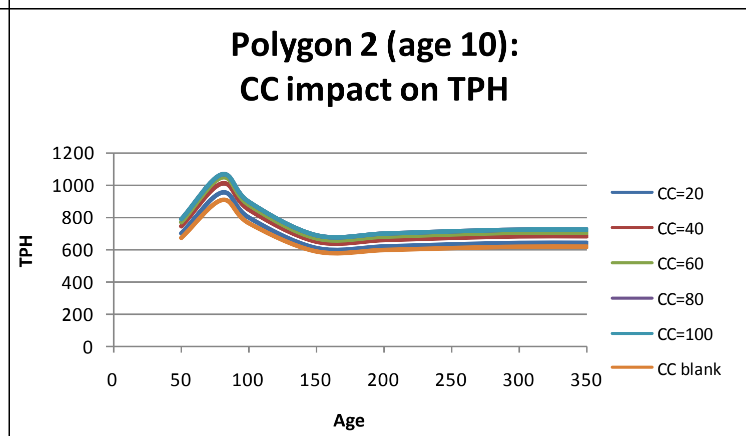
Appendix E_1: Effect of % crown closure change on BA and TPH over time

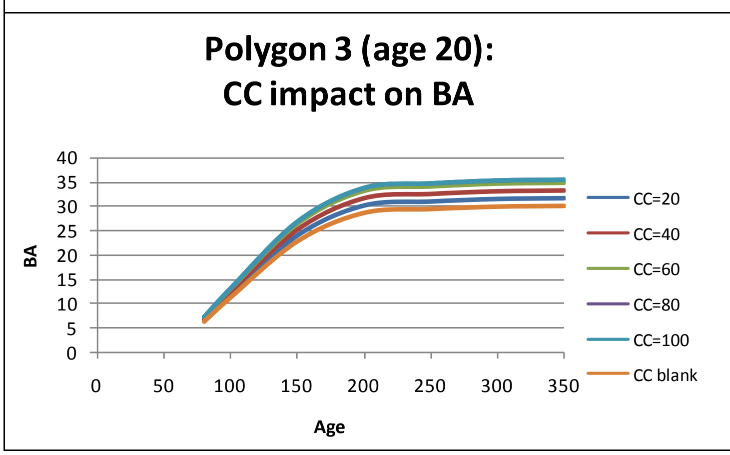
Polygons <30 years of age at reference year

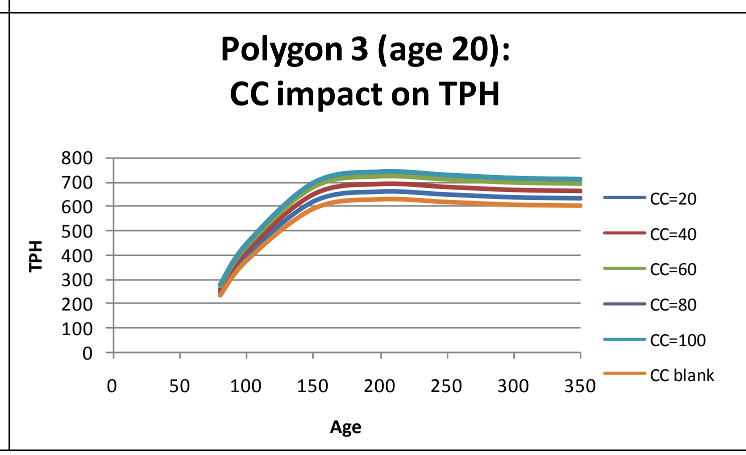


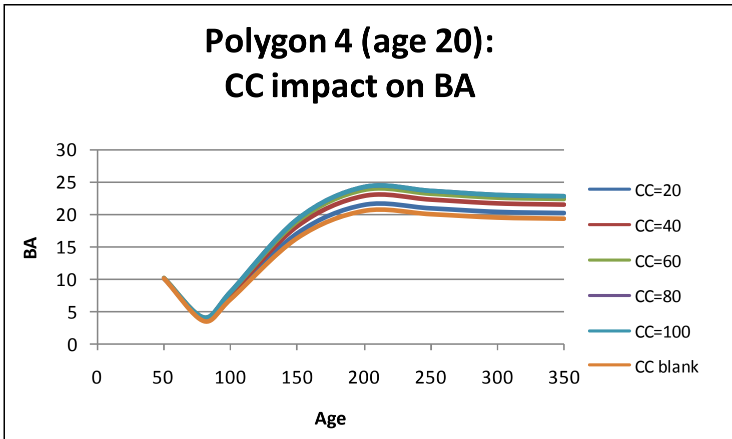


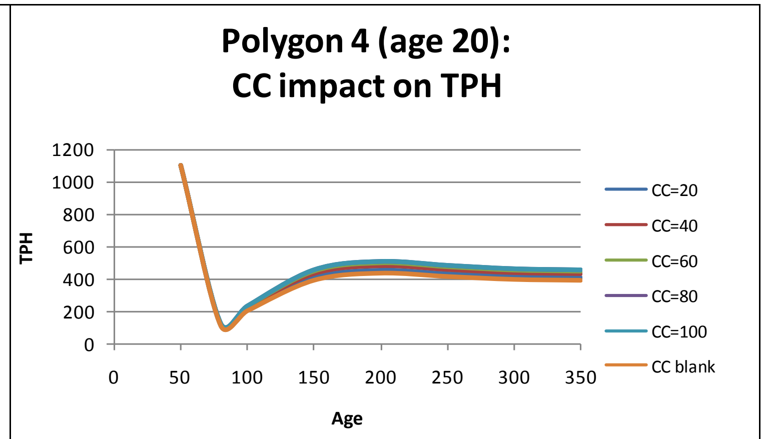


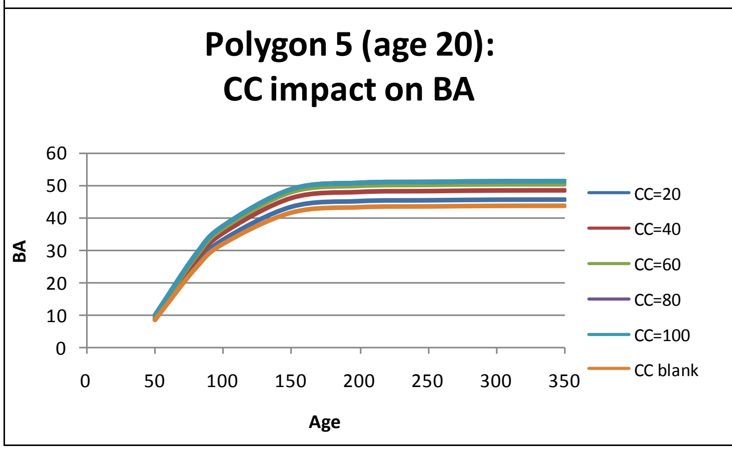


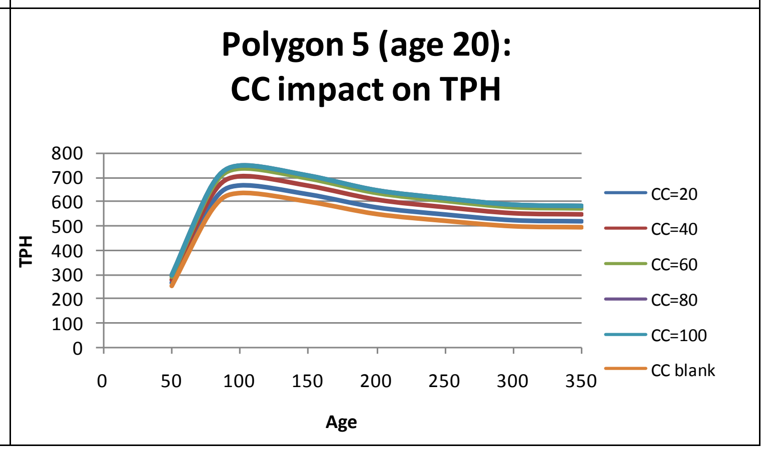





Polygon 4 (age 20):
CC impact on BA
BA
30
25
20
15
10
5
0
0 50 100 150 200 250 300 350
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

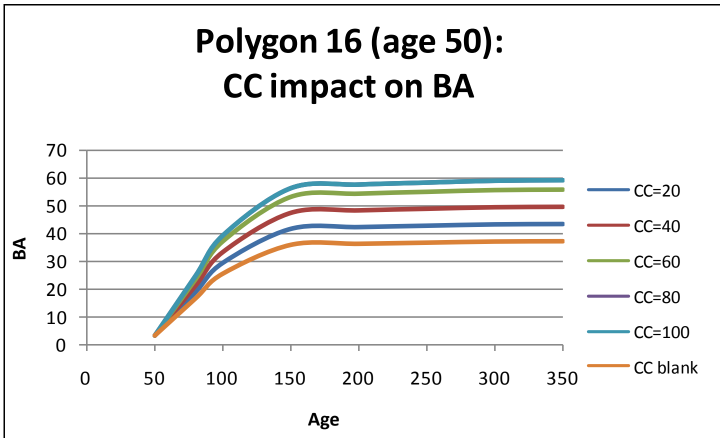

Polygon 4 (age 20):
CC impact on TPH
TPH
1200
1000
800
600
400
200
0
0 50 100 150 200 250 300 350
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

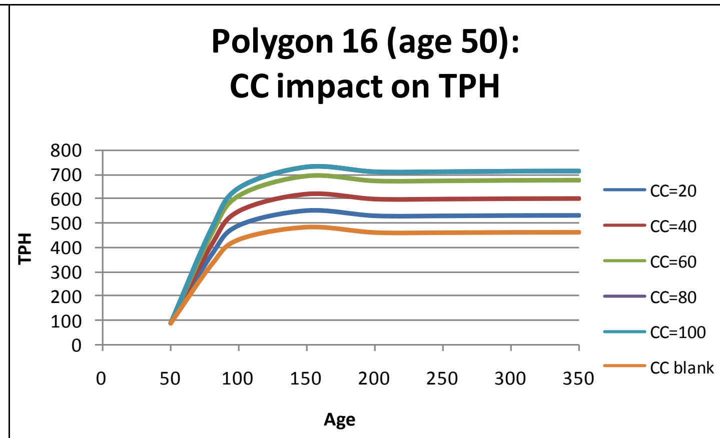

Polygon 5 (age 20):
CC impact on BA
BA
60
50
40
30
20
10
0
0 50 100 150 200 250 300 350
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

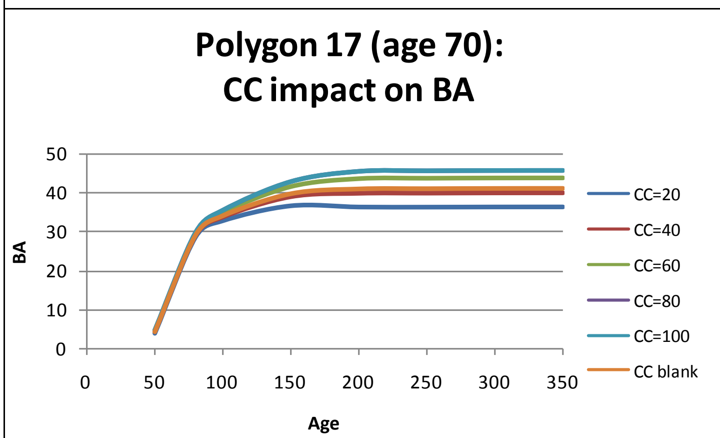

Polygon 5 (age 20):
CC impact on TPH
TPH
800
700
600
500
400
300
200
100
0
0 50 100 150 200 250 300 350
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

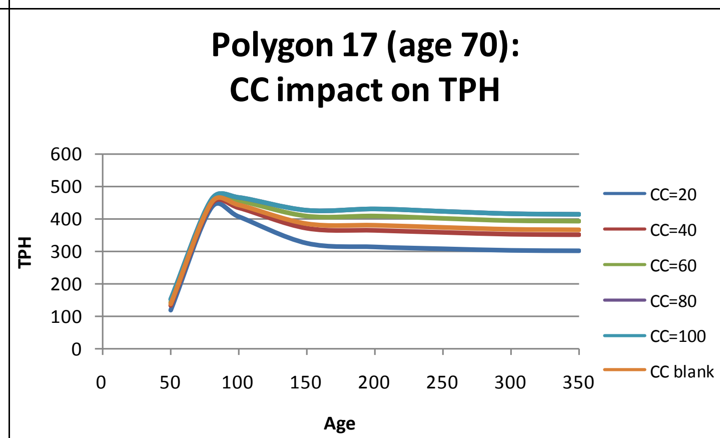
Appendix E_2: Effect of % crown closure change on BA and TPH over time

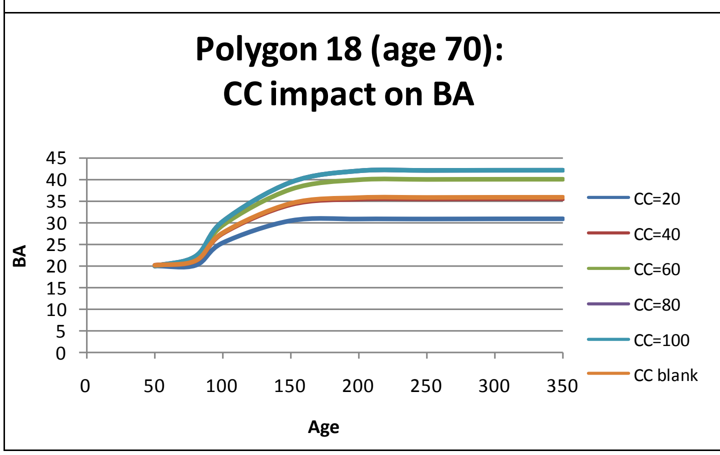
Polygons 30 to 80 years of age at reference year

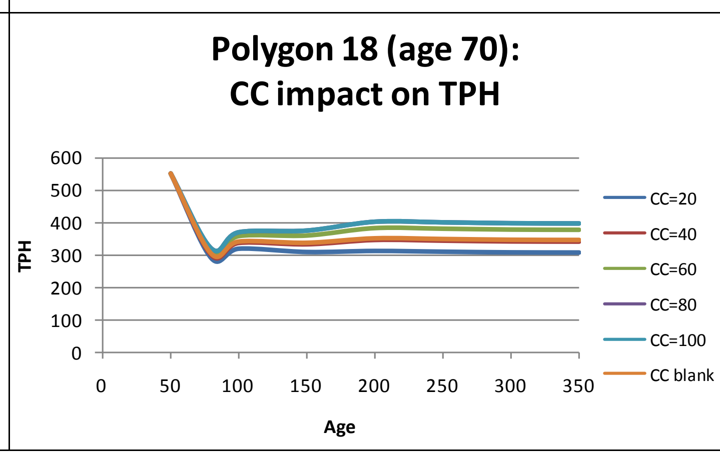


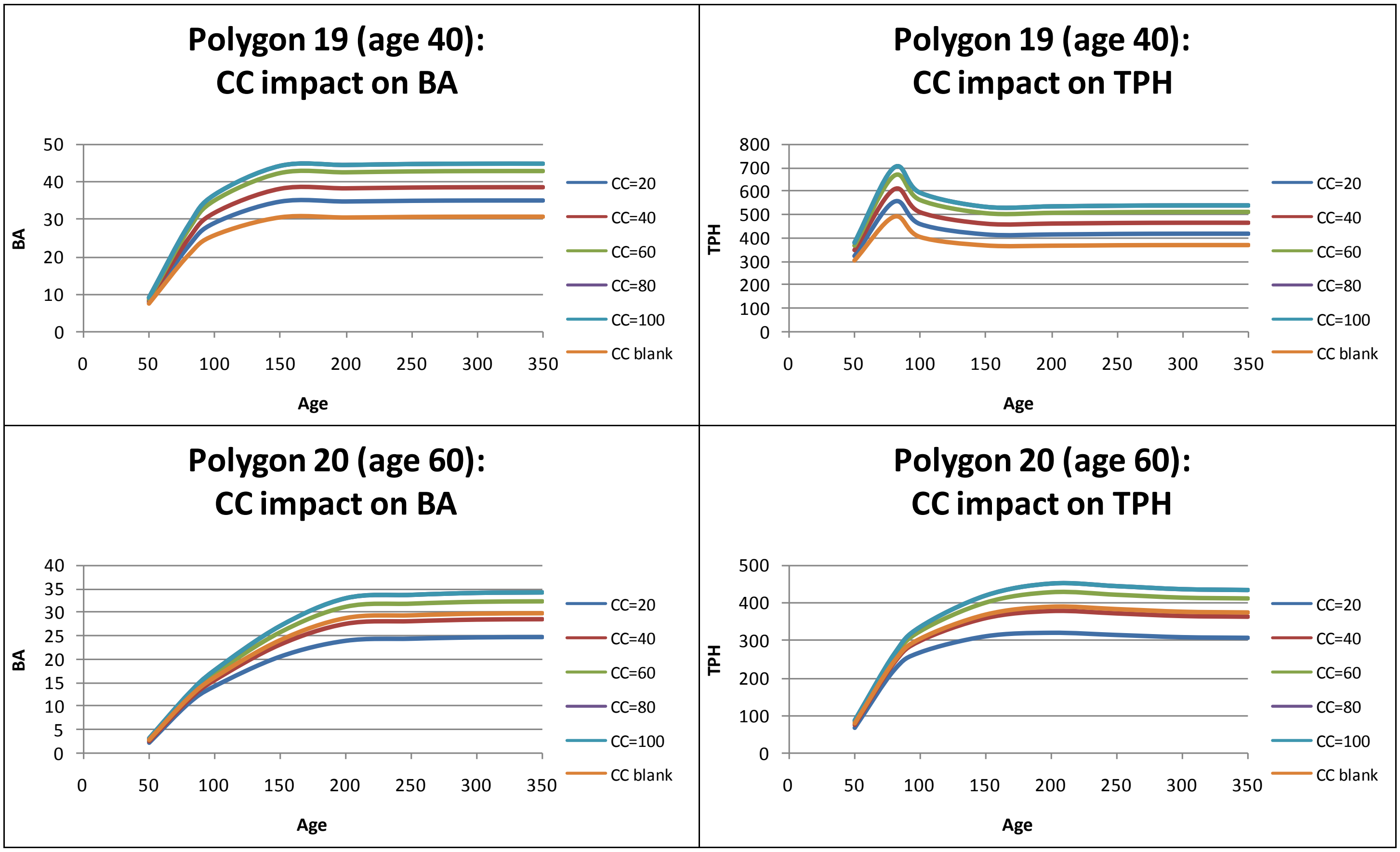






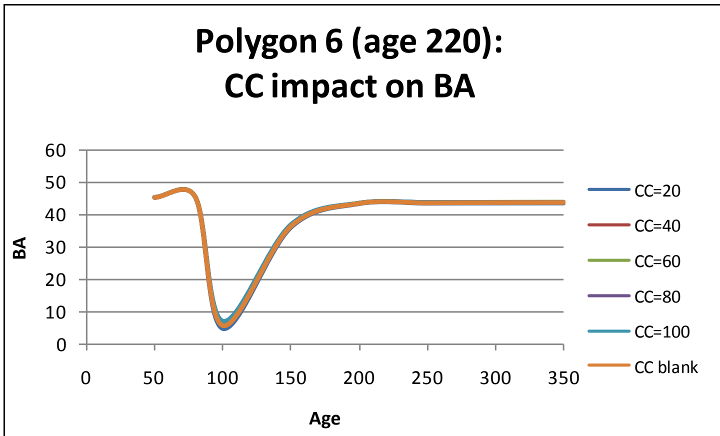


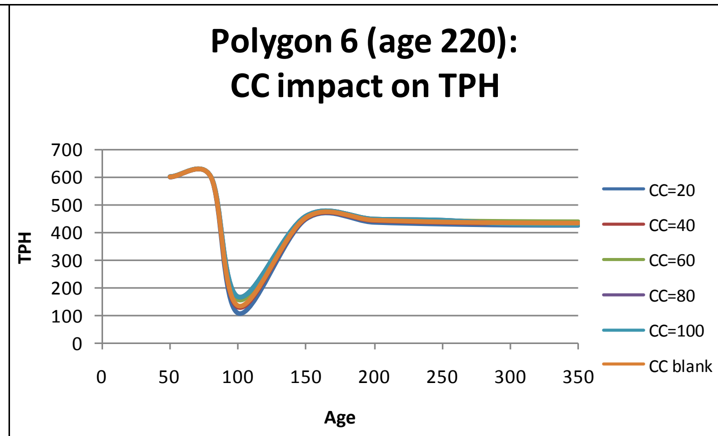


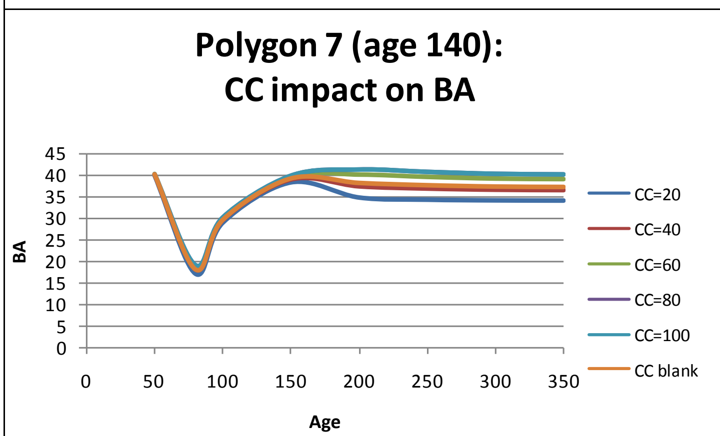

Polygon 19 (age 40):
CC impact on BA
BA
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank
Polygon 19 (age 40):
CC impact on TPH
TPH
Age
Polygon 20 (age 60):
CC impact on BA
BA
Age
Polygon 20 (age 60):
CC impact on TPH
TPH
Age

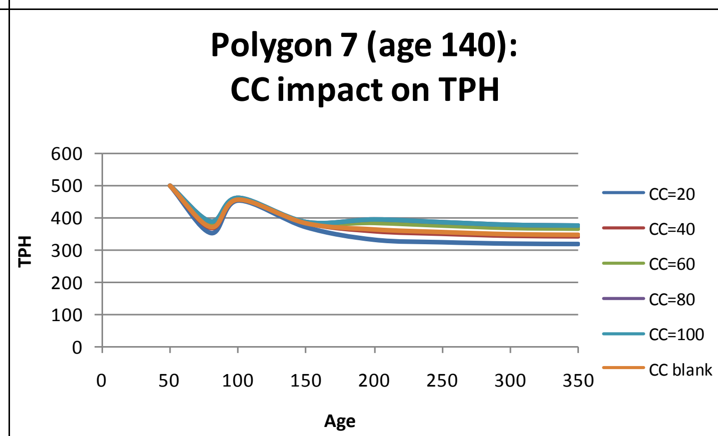
Appendix E_3: Effect of % crown closure change on BA and TPH over time

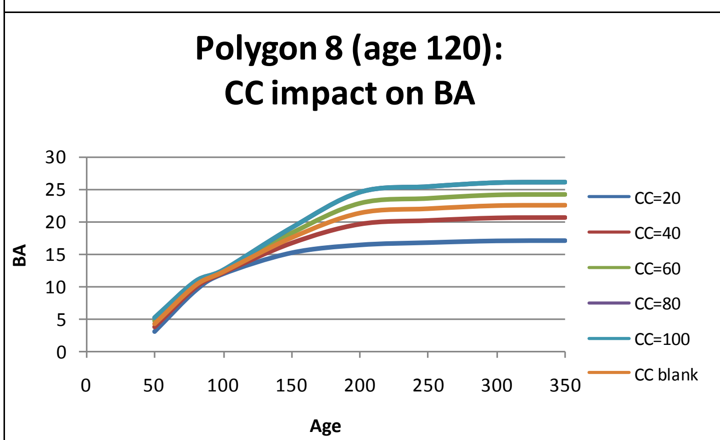
Polygons 81 to 249 years of age at reference year

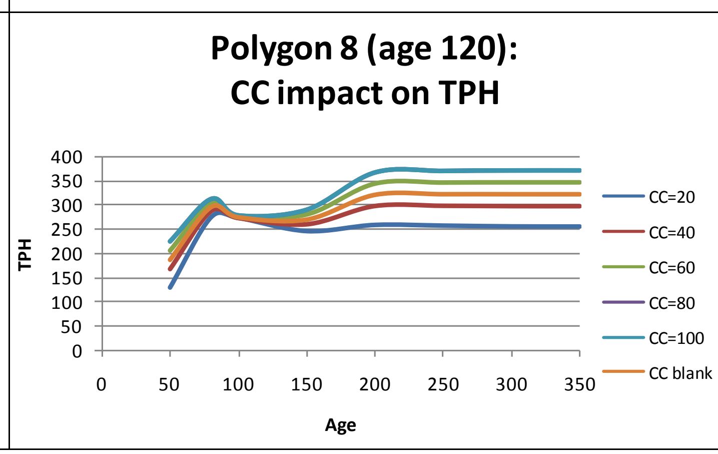


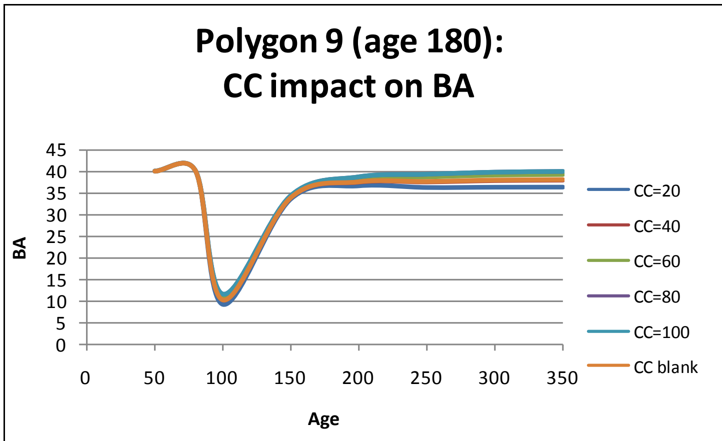


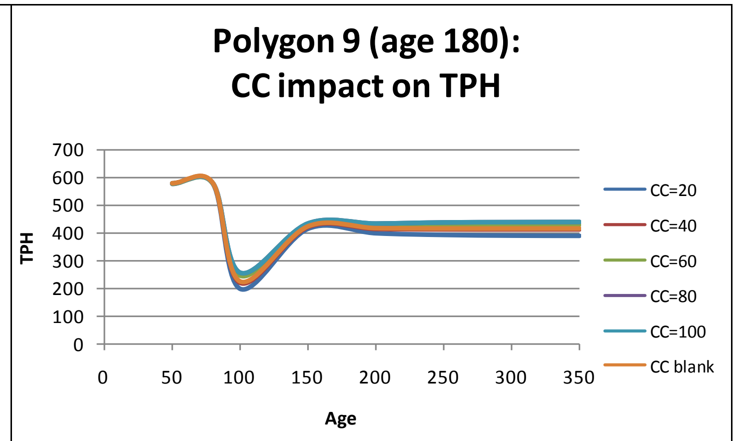


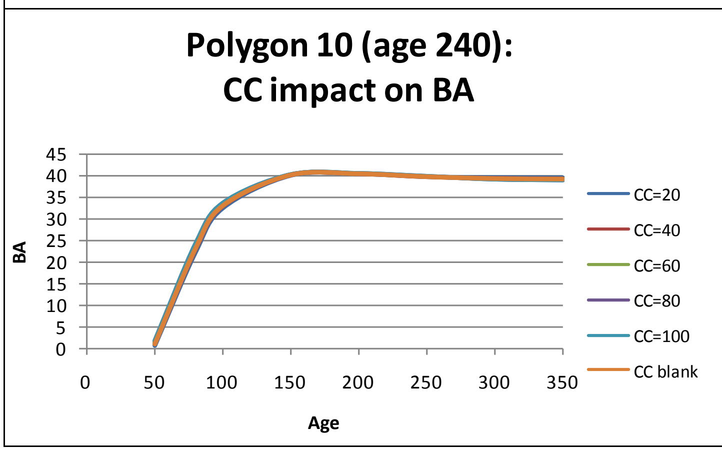


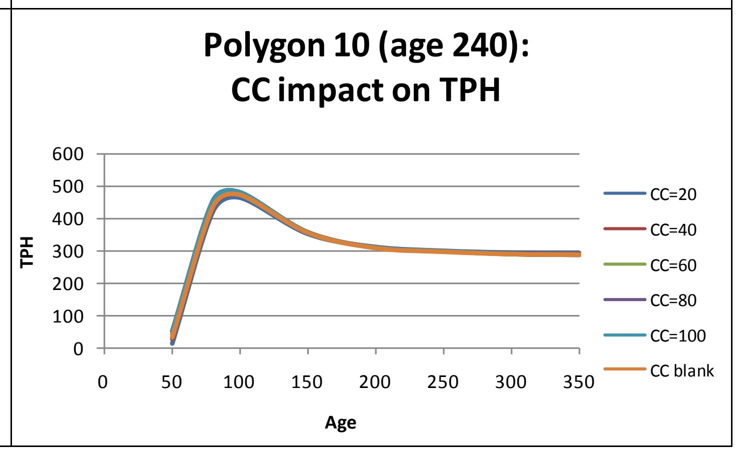





Polygon 9 (age 180):
CC impact on BA
BA
45
40
35
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

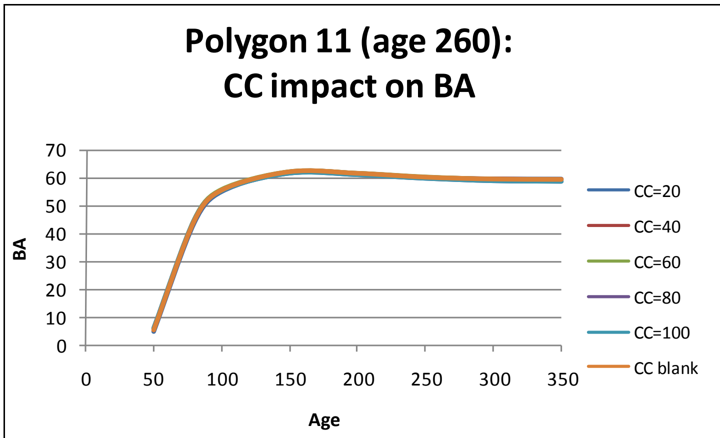

Polygon 9 (age 180):
CC impact on TPH
TPH
700
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

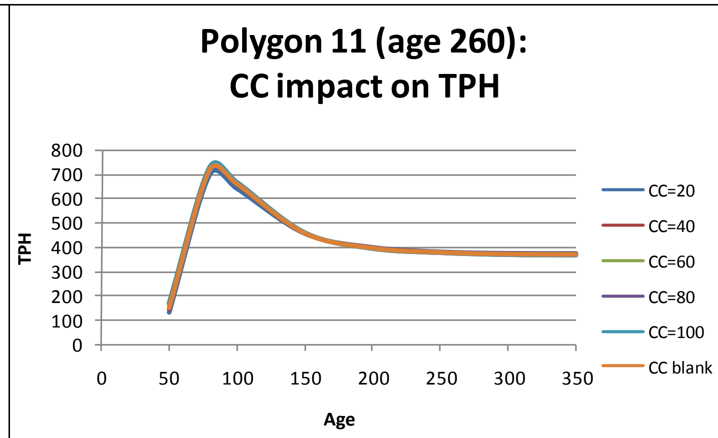

Polygon 10 (age 240):
CC impact on BA
BA
45
40
35
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

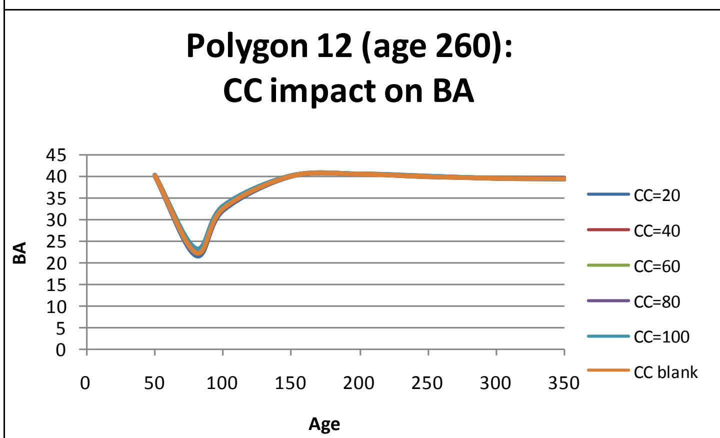

Polygon 10 (age 240):
CC impact on TPH
TPH
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

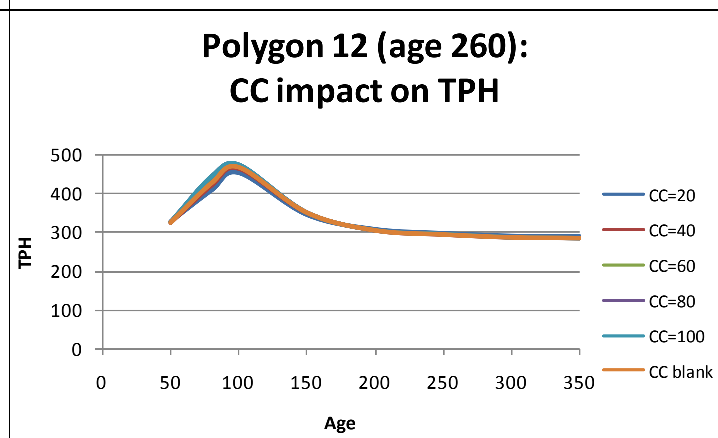
Appendix E_4: Effect of % crown closure change on BA and TPH over time

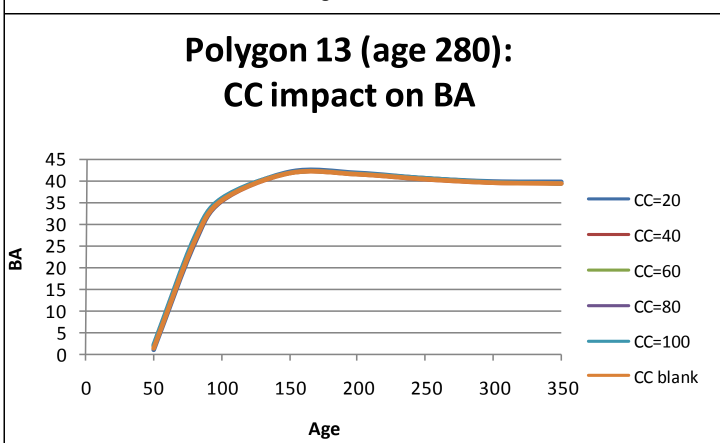
Polygons 250+ years of age at reference year

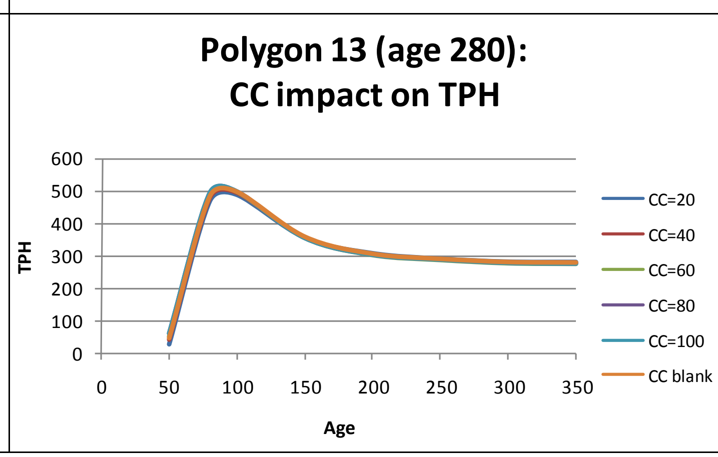


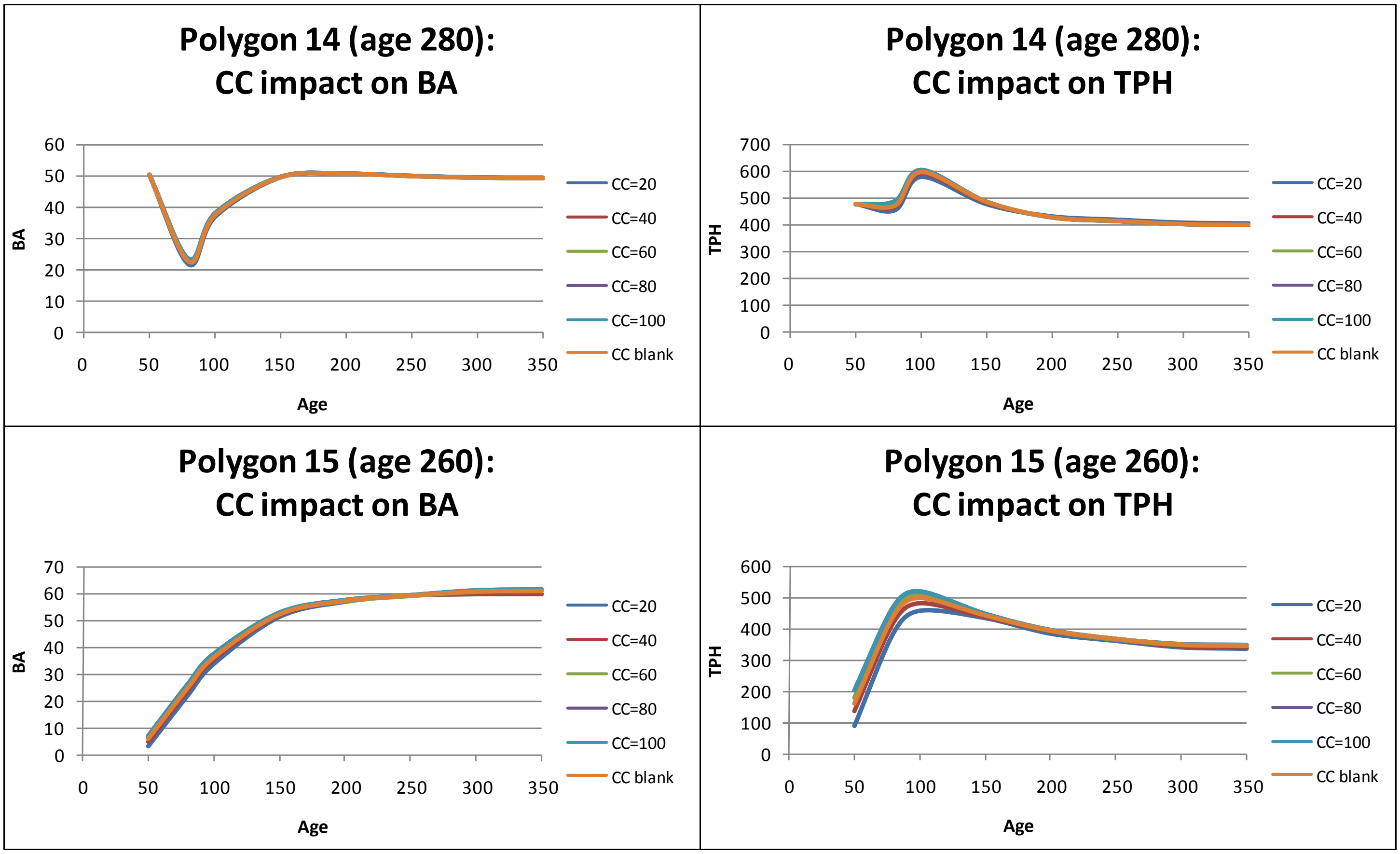








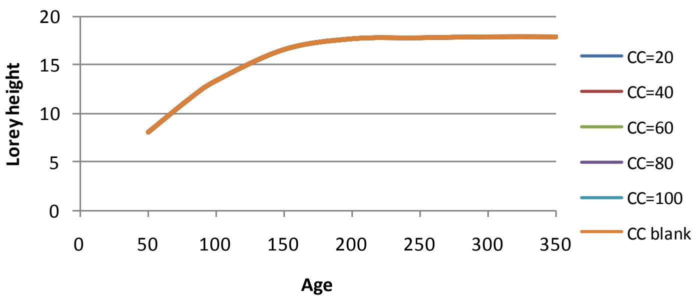



Polygon 14 (age 280):
CC impact on BA
BA
Age
0
10
20
30
40
50
60
0
50
100
150
200
250
300
350
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank
Polygon 14 (age 280):
CC impact on TPH
TPH
Age
0
100
200
300
400
500
600
700
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank
Polygon 15 (age 260):
CC impact on BA
BA
Age
70
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank
Polygon 15 (age 260):
CC impact on TPH
TPH
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

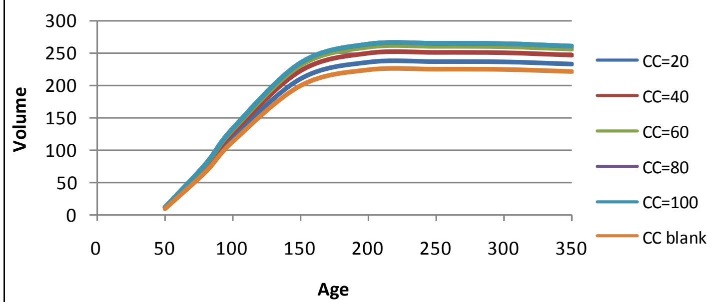
Appendix F_1: Effect of CC% change on Lorey height and volume over time

Polygons <30 years of age at reference year

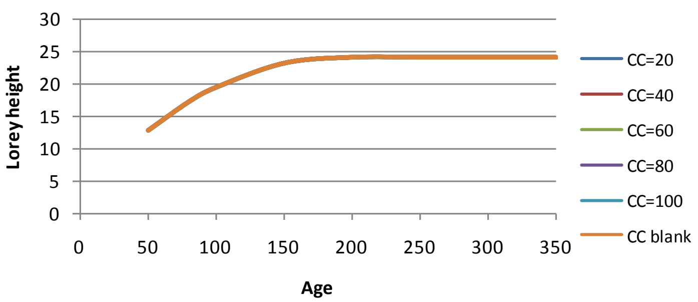
Polygon 1 (age 15): CC impact on Lorey height



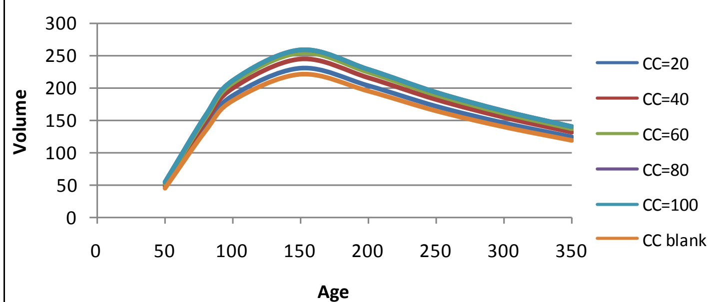
Polygon 1 (age 15): CC impact on Volume



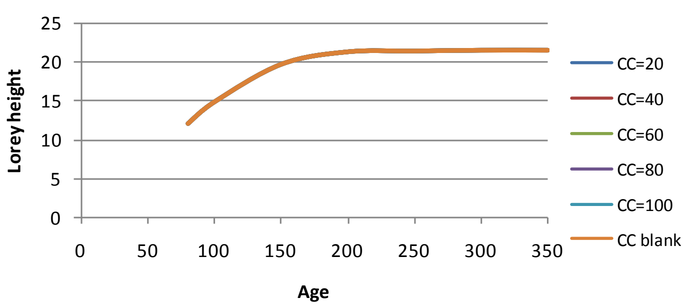
Polygon 2 (age 10): CC impact on Lorey height



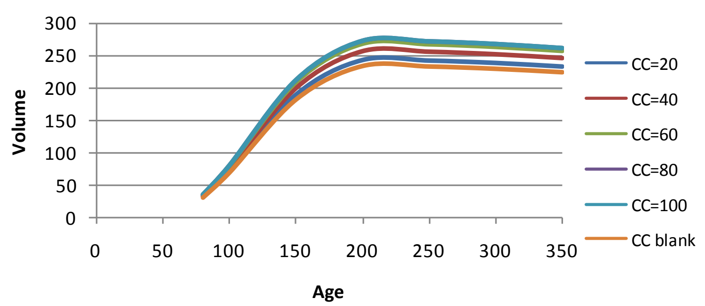
Polygon 2 (age 10): CC impact on Volume

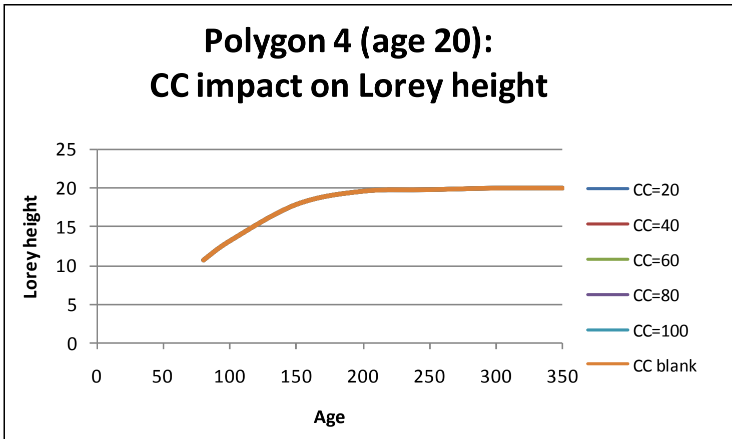


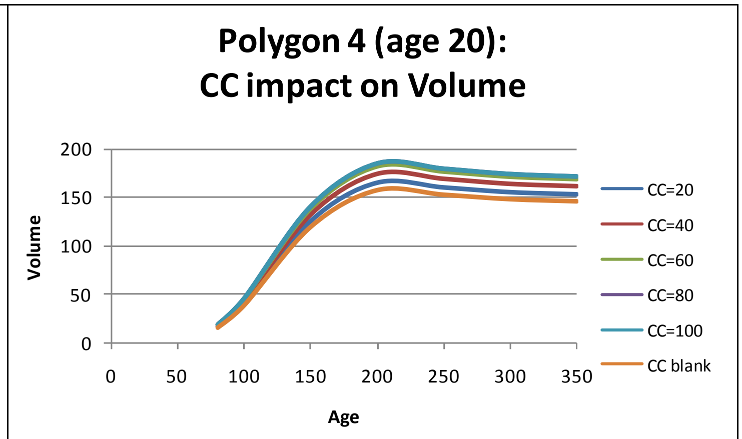
Polygon 3 (age 20): CC impact on Lorey height

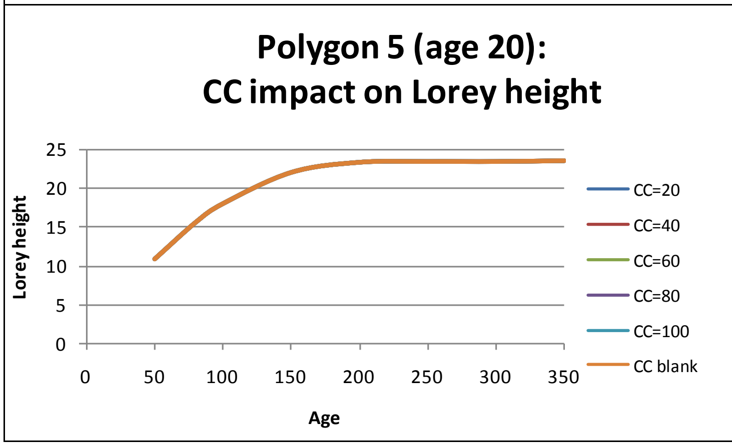


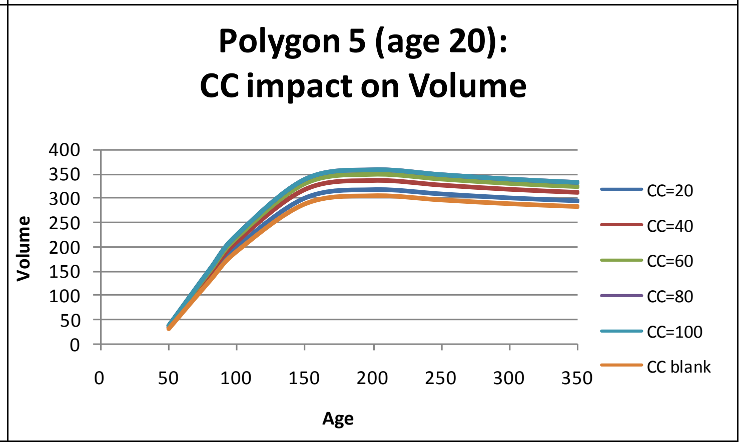
Polygon 3 (age 20): CC impact on Volume




Polygon 4 (age 20):
CC impact on Lorey height
Lorey height
Age
0
5
10
15
20
25
0
50
100
150
200
250
300
350
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

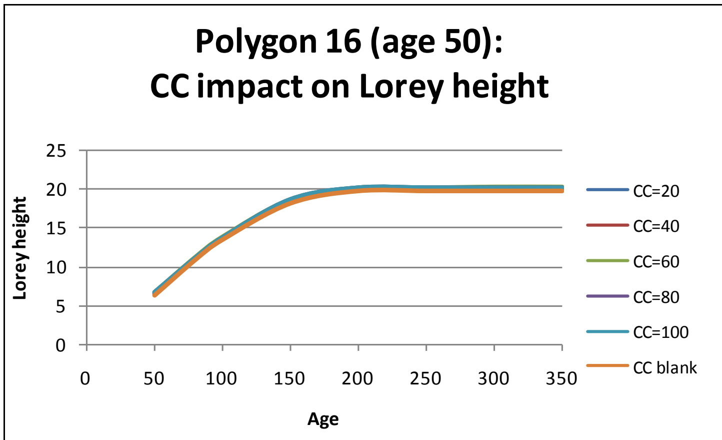

Polygon 4 (age 20):
CC impact on Volume
Volume
Age
0
50
100
150
200
0
50
100
150
200
250
300
350
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

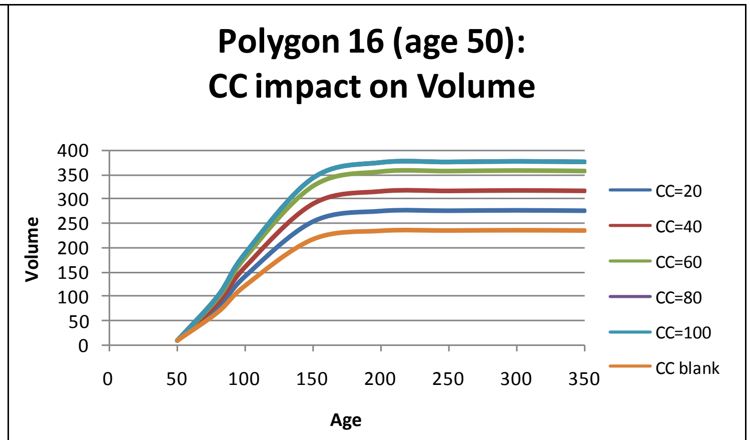

Polygon 5 (age 20):
CC impact on Lorey height
Lorey height
Age
0
5
10
15
20
25
0
50
100
150
200
250
300
350
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

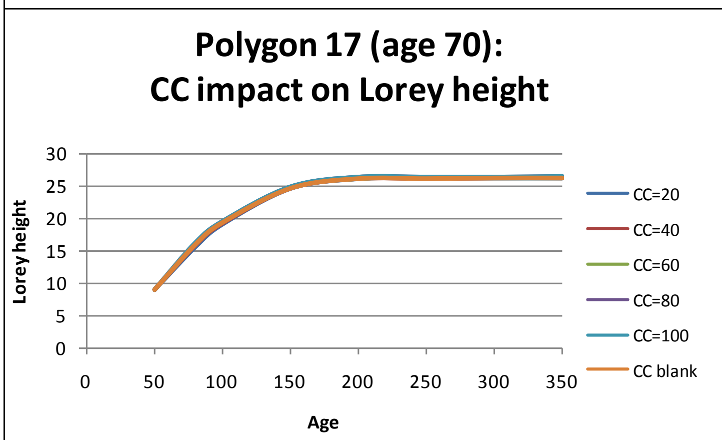

Polygon 5 (age 20):
CC impact on Volume
Volume
Age
0
50
100
150
200
250
300
350
400
0
50
100
150
200
250
300
350
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

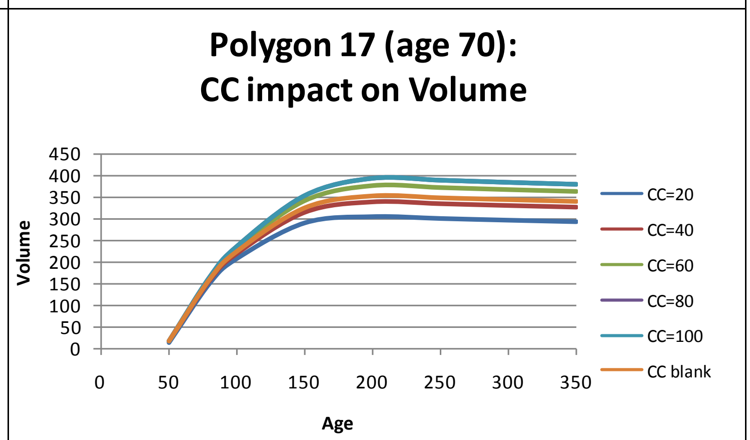
Appendix F_2: Effect of CC% change on Lorey height and volume over time

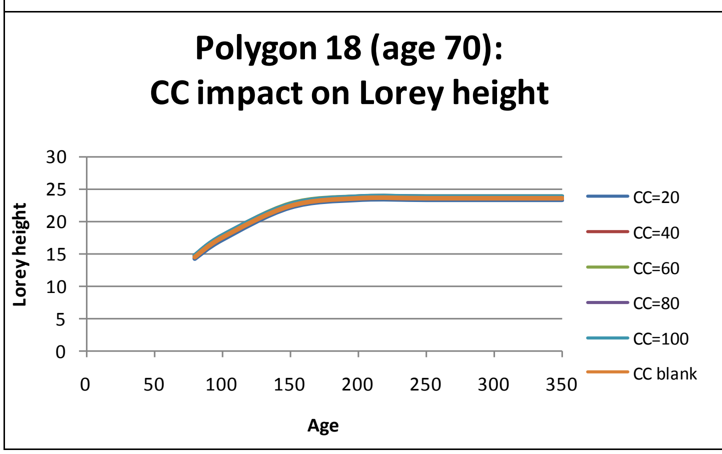
Polygons 30 to 80 years of age at reference year

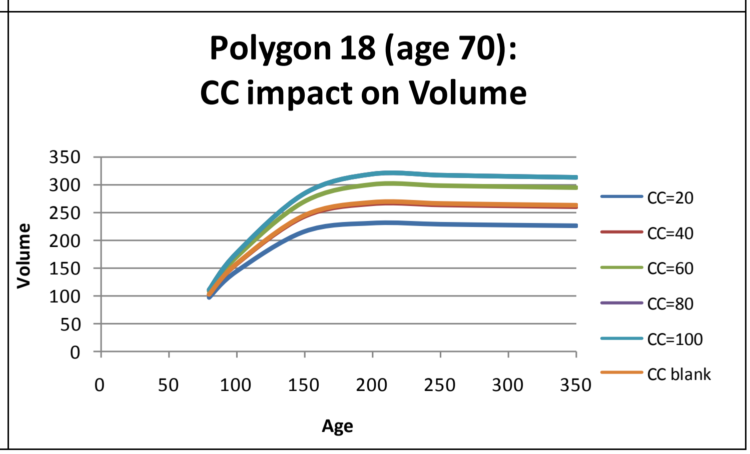


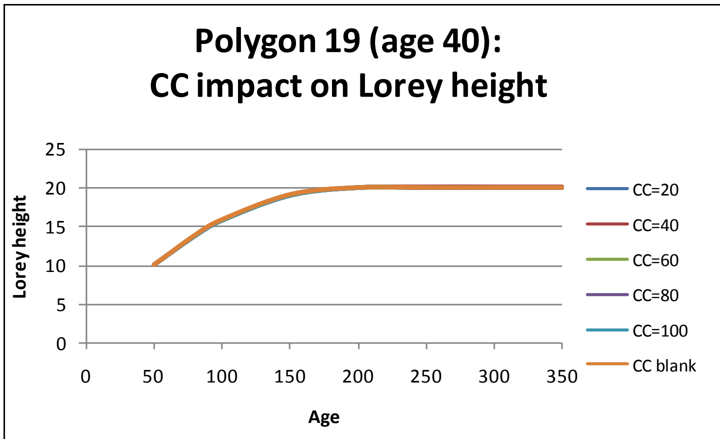


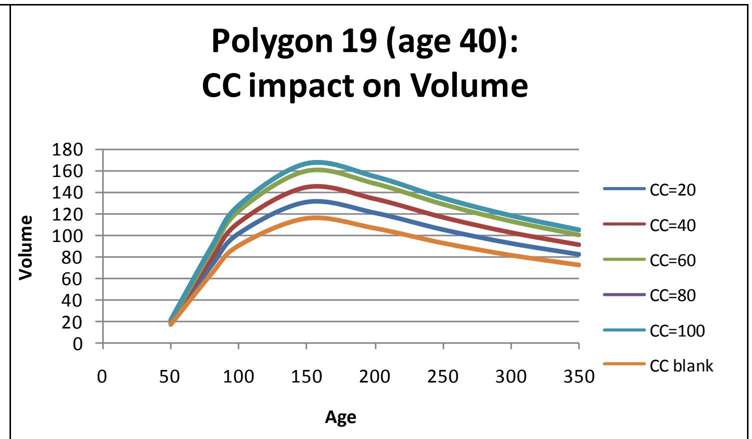


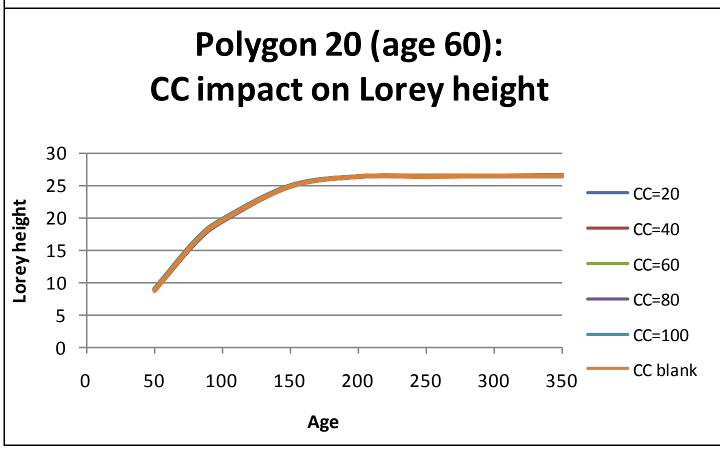


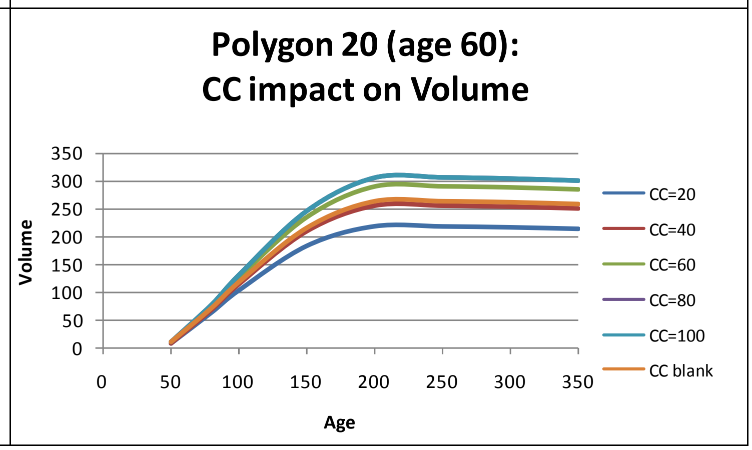





Polygon 19 (age 40):
CC impact on Lorey height
Lorey height
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

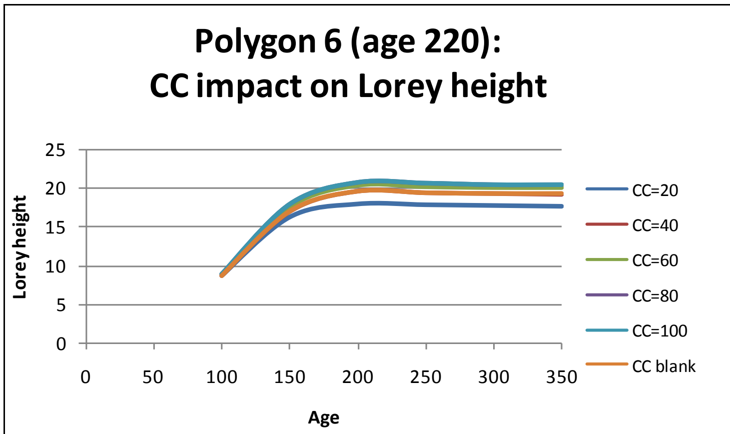

Polygon 19 (age 40):
CC impact on Volume
Volume
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

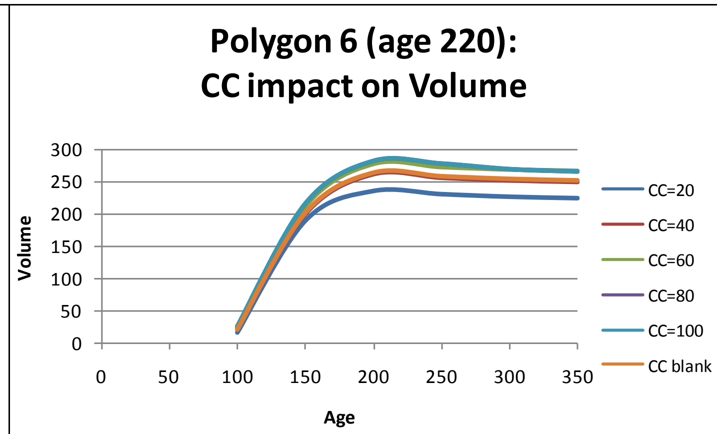

Polygon 20 (age 60):
CC impact on Lorey height
Lorey height
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

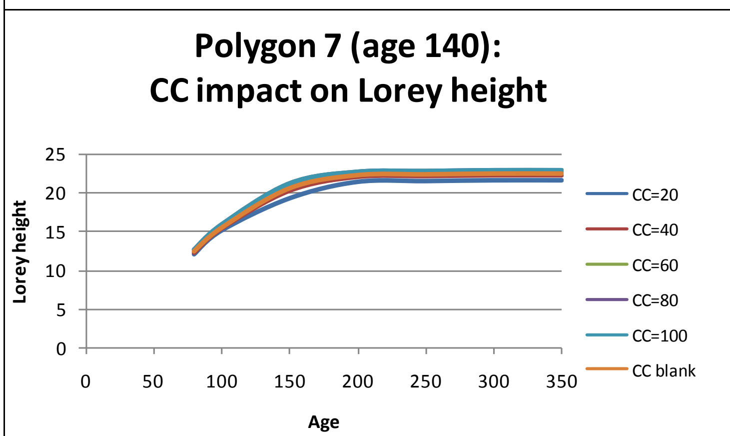

Polygon 20 (age 60):
CC impact on Volume
Volume
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

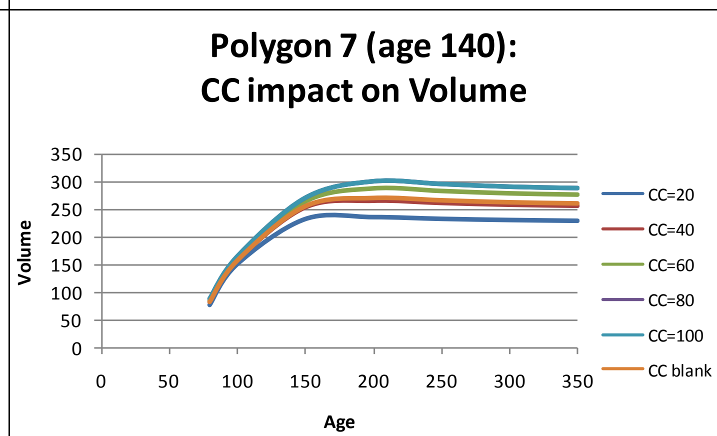
Appendix F$_3$: Effect of CC% change on Lorey height and volume over time

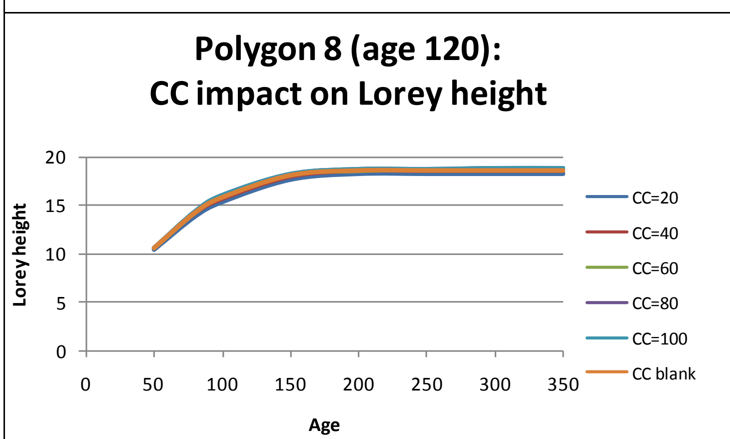
Polygons 81 to 249 years of age at reference year

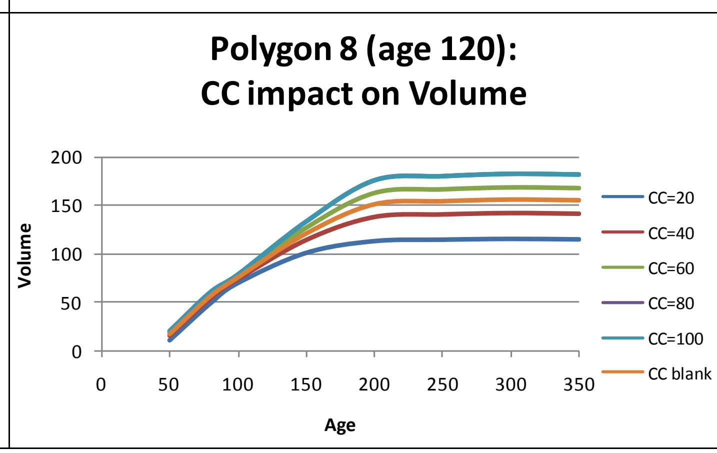


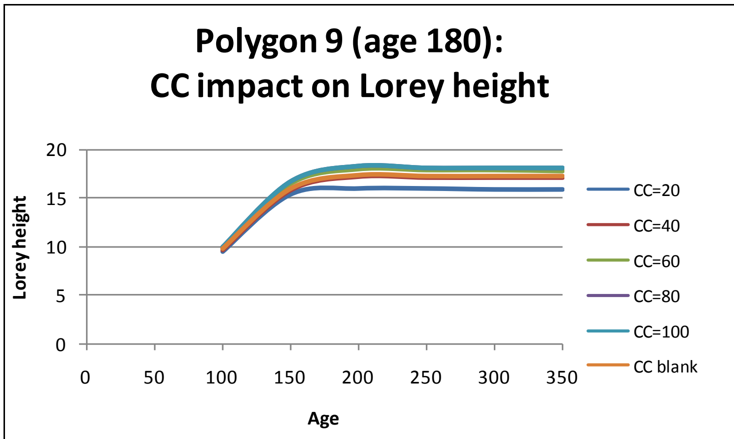


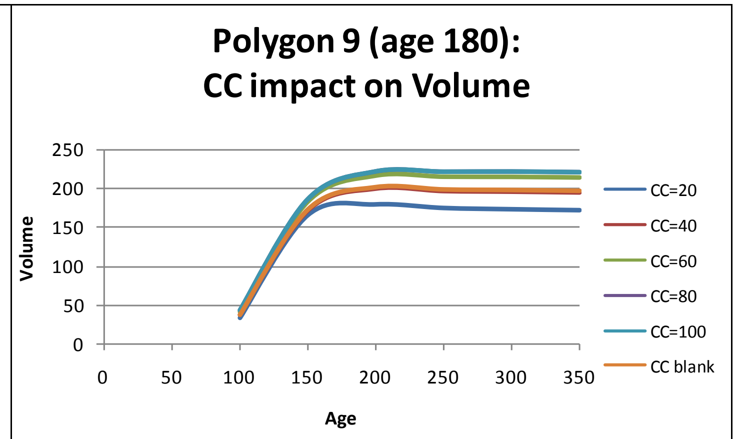


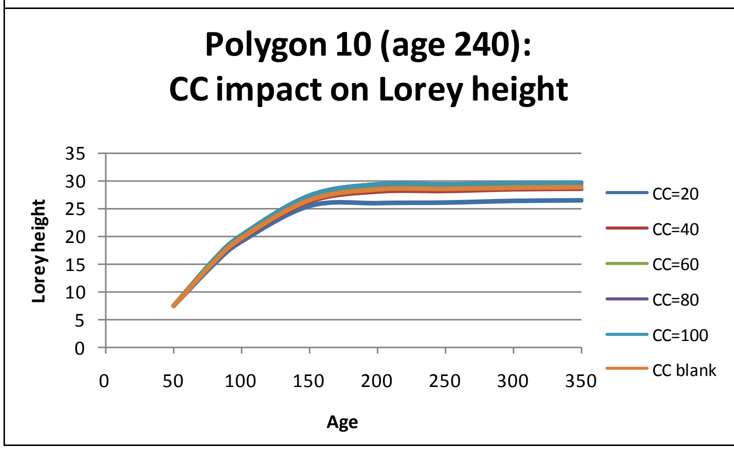


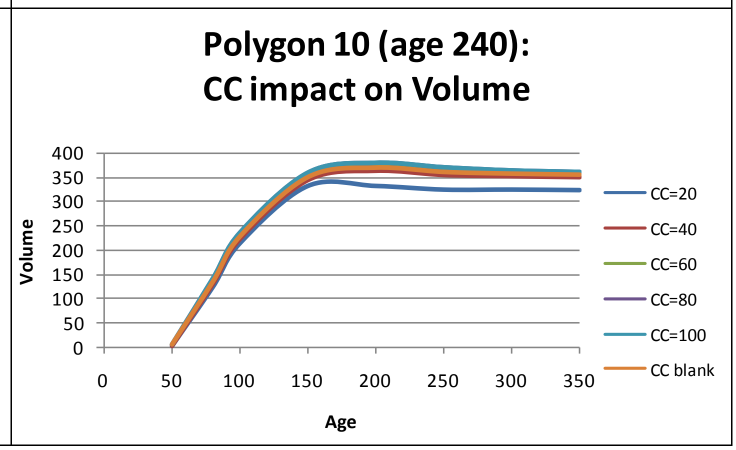





Polygon 9 (age 180):
CC impact on Lorey height
Lorey height
Age
0
5
10
15
20
0
50
100
150
200
250
300
350
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

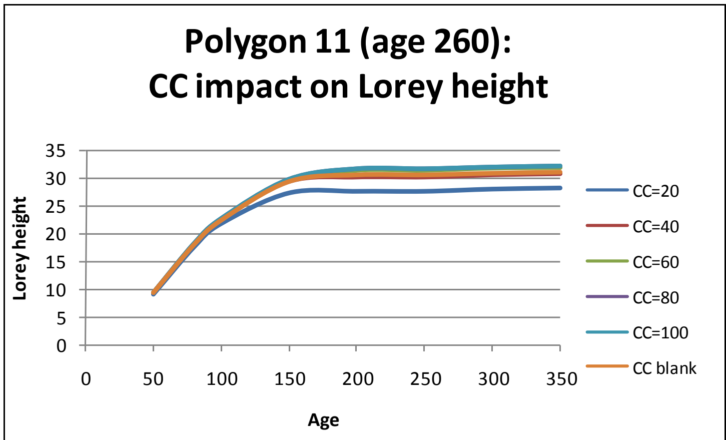

Polygon 9 (age 180):
CC impact on Volume
Volume
Age
0
50
100
150
200
250
0
50
100
150
200
250
300
350
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

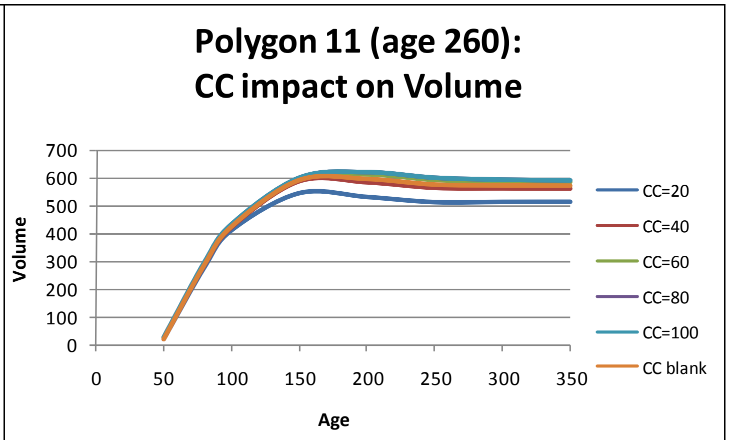

Polygon 10 (age 240):
CC impact on Lorey height
Lorey height
Age
0
5
10
15
20
25
30
35
0
50
100
150
200
250
300
350
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

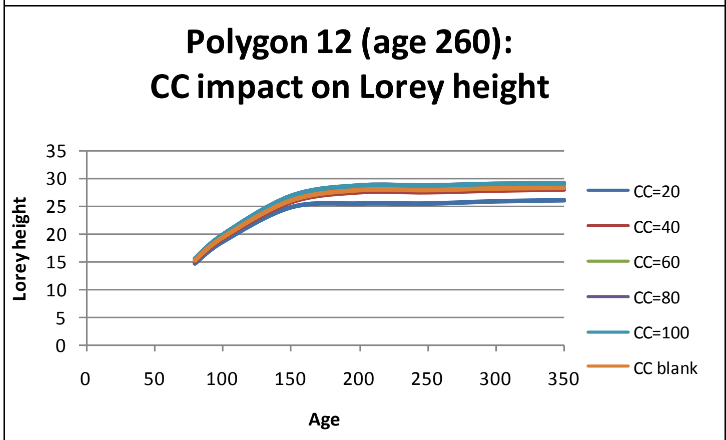

Polygon 10 (age 240):
CC impact on Volume
Volume
Age
0
50
100
150
200
250
300
350
400
0
50
100
150
200
250
300
350
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

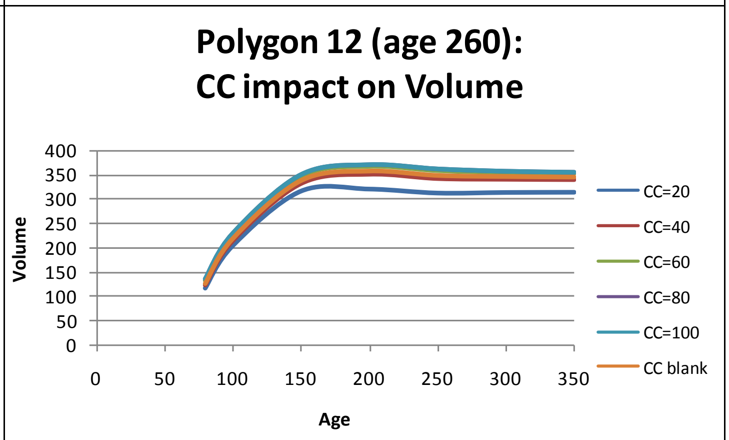
Appendix F_4: Effect of CC% change on Lorey height and volume over time

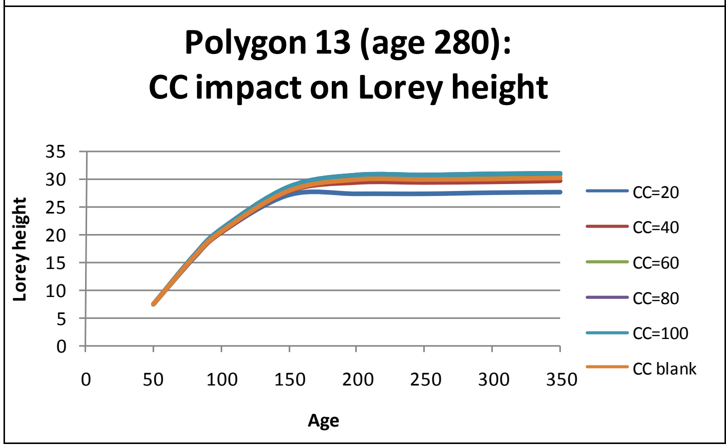
Polygons 250+ years of age at reference year

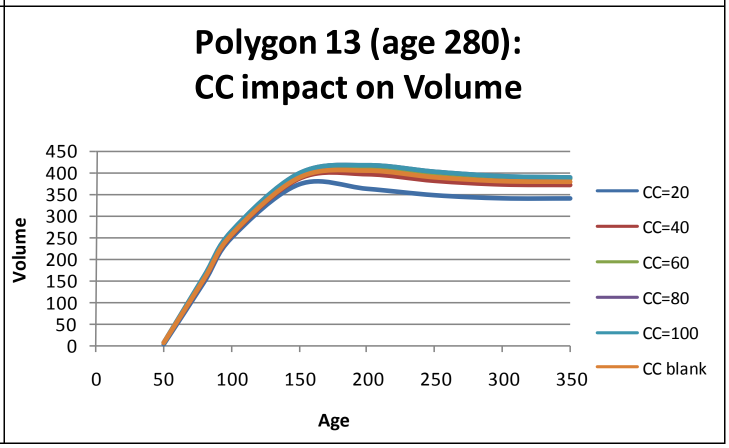


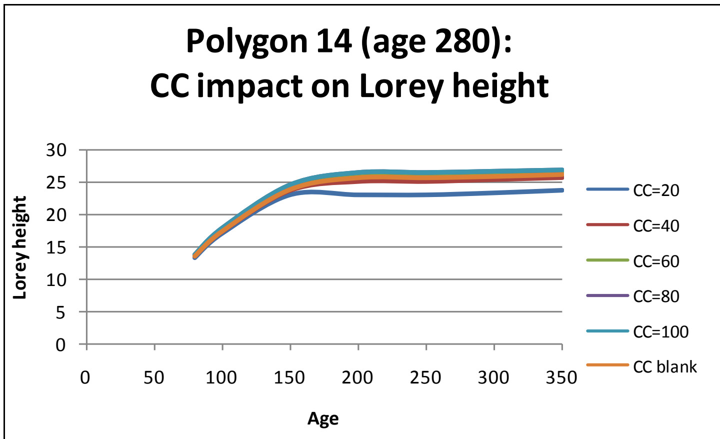


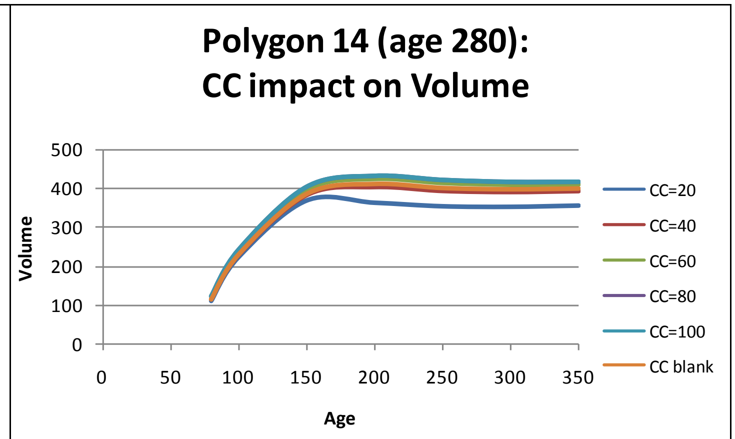


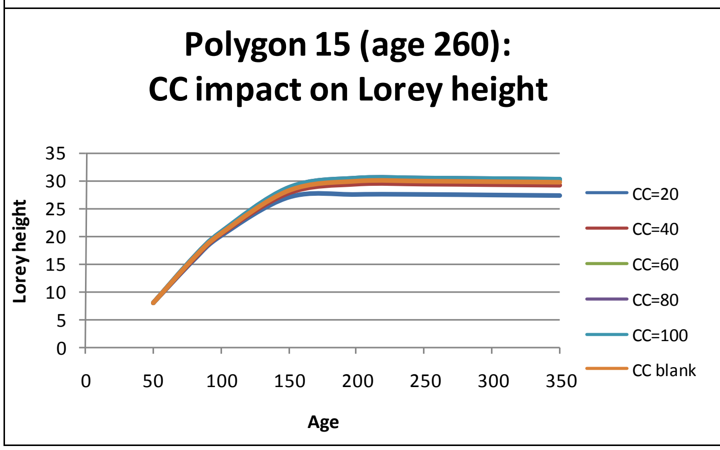


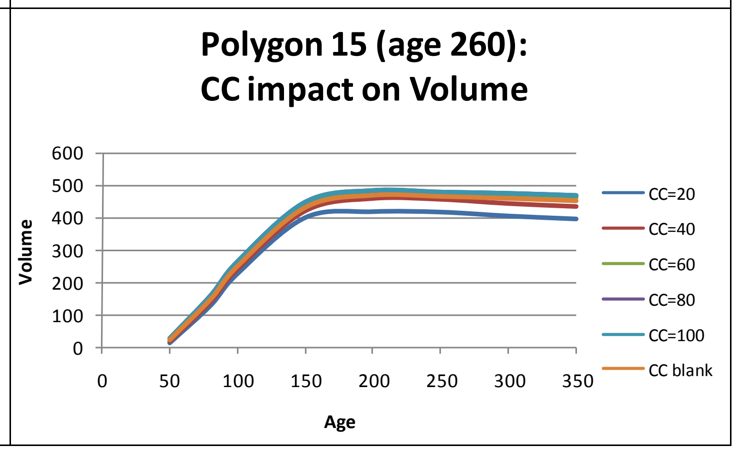





Polygon 14 (age 280):
CC impact on Lorey height
Lorey height
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank


Polygon 14 (age 280):
CC impact on Volume
Volume
500
400
300
200
100
0
0
50
100
150
200
250
300
350
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

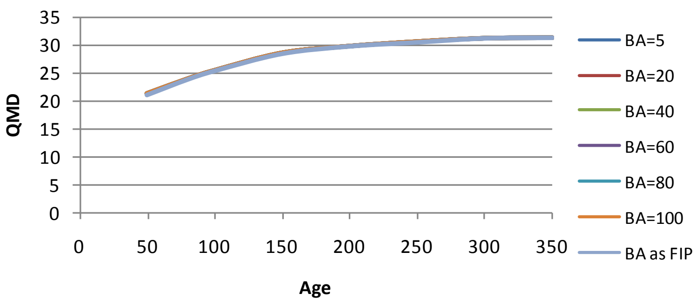

Polygon 15 (age 260):
CC impact on Lorey height
Lorey height
35
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank


Polygon 15 (age 260):
CC impact on Volume
Volume
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
Age
CC=20
CC=40
CC=60
CC=80
CC=100
CC blank

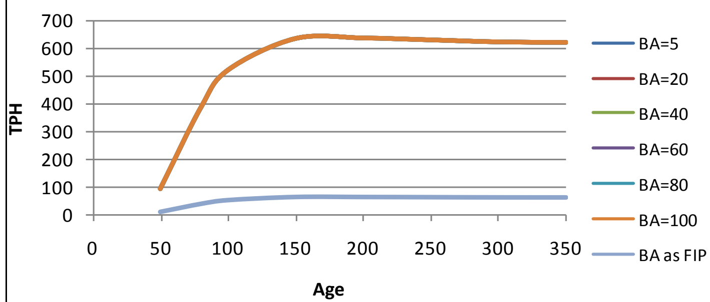
Appendix G_1: Effect of basal area change on QMD and TPH over time

Polygons <30 years of age at reference year

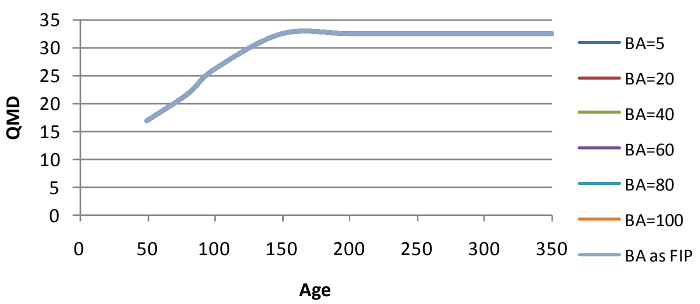
Polygon 1 (age 15): BA impact on QMD



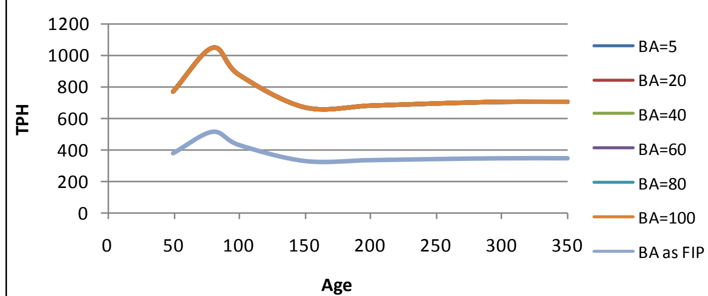
Polygon 1 (age 15): BA impact on TPH



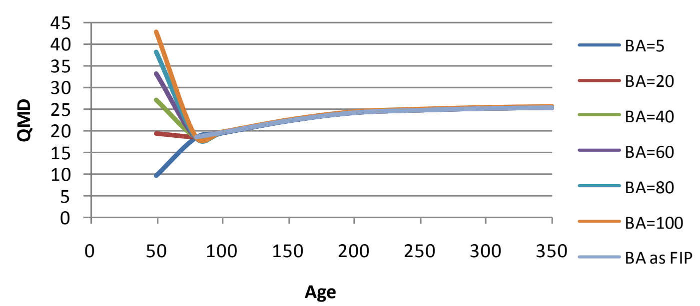
Polygon 2 (age 10): BA impact on QMD



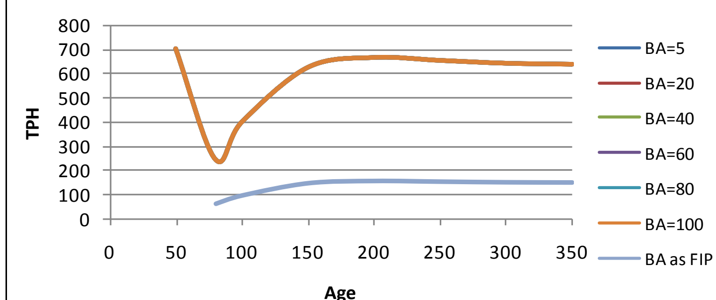
Polygon 2 (age 10): BA impact on TPH

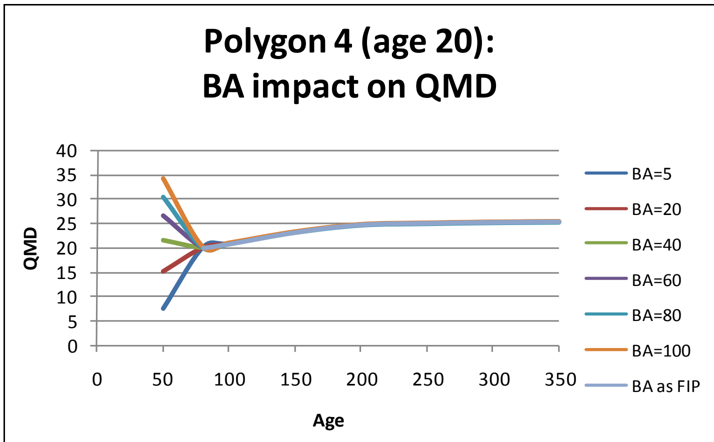


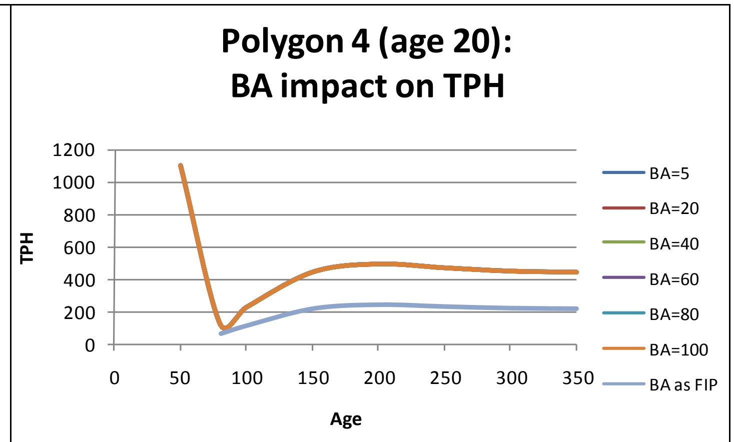
Polygon 3 (age 20): BA impact on QMD

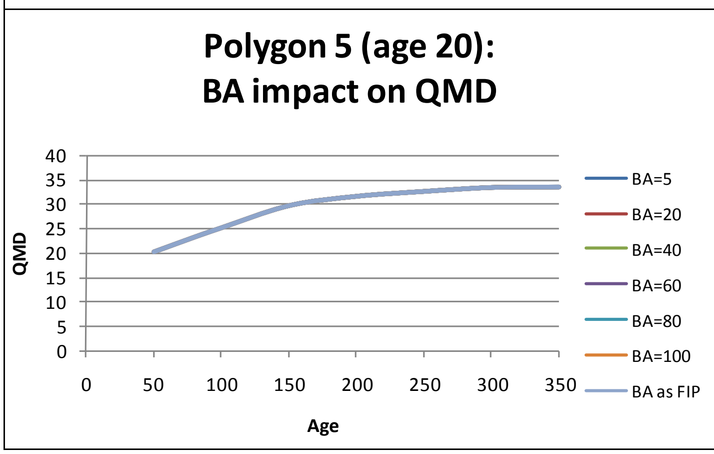


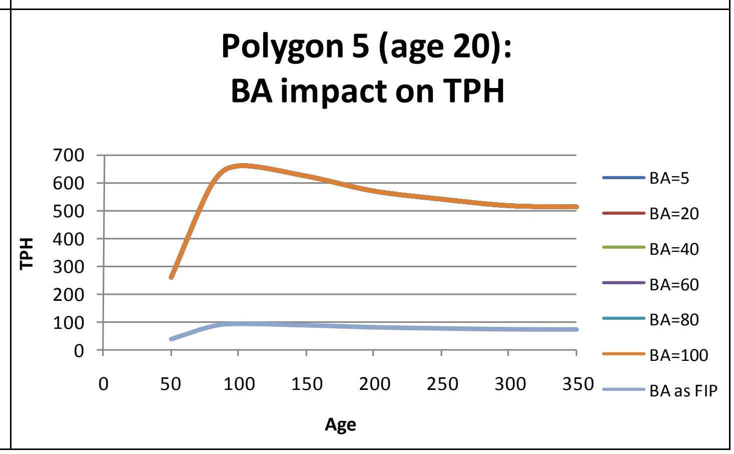
Polygon 3 (age 20): BA impact on TPH




Polygon 4 (age 20):
BA impact on QMD
QMD
40
35
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

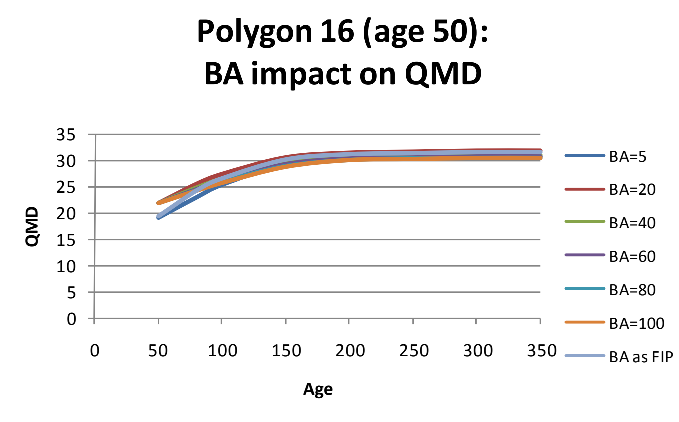

Polygon 4 (age 20):
BA impact on TPH
TPH
1200
1000
800
600
400
200
0
0
50
100
150
200
250
300
350
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

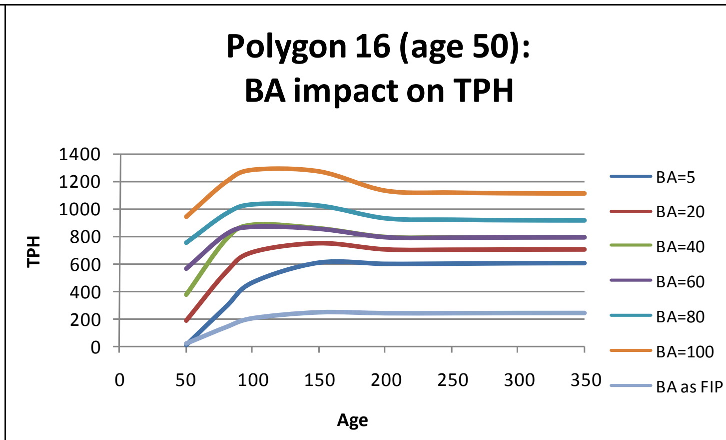

Polygon 5 (age 20):
BA impact on QMD
QMD
40
35
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

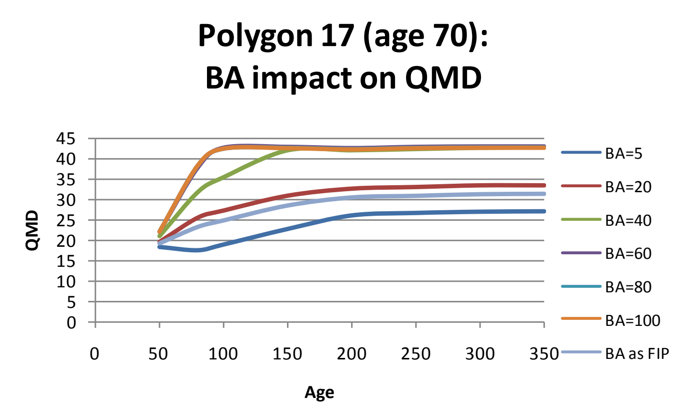

Polygon 5 (age 20):
BA impact on TPH
TPH
700
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

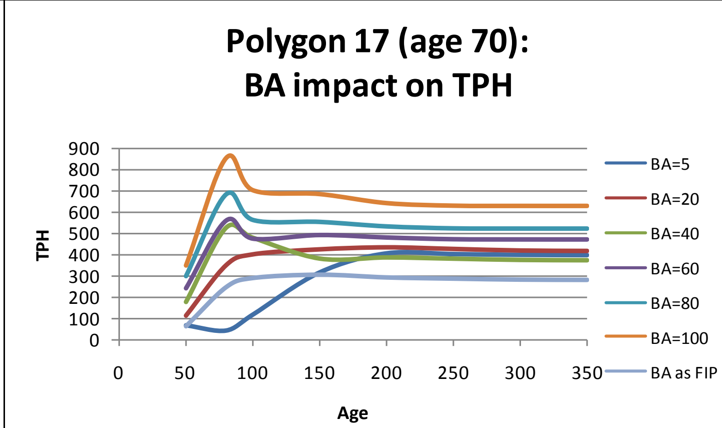
Appendix G_2: Effect of basal area change on QMD and TPH over time

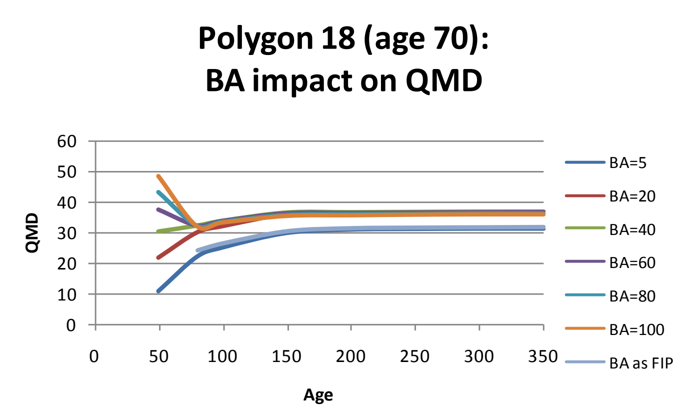
Polygons 30 to 80 years of age at reference year

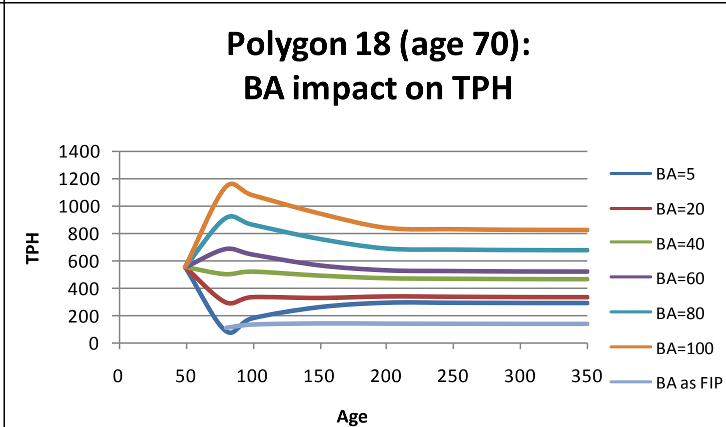


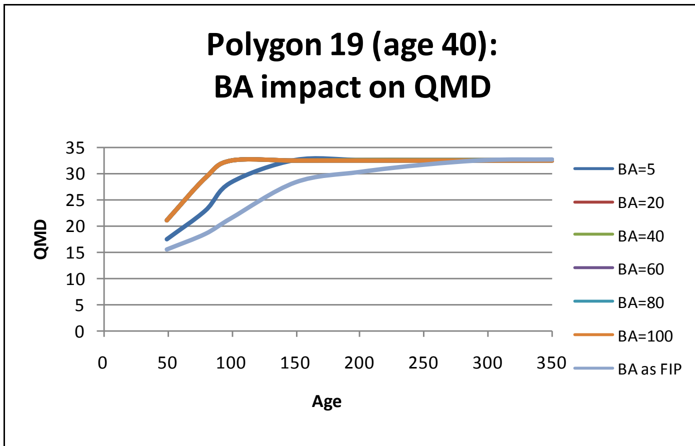


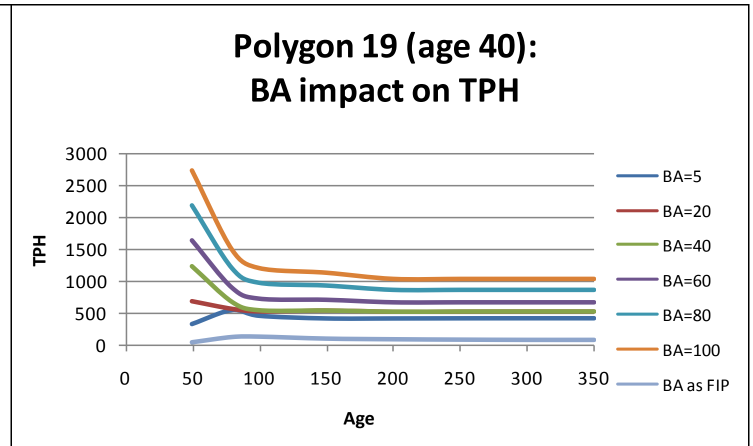


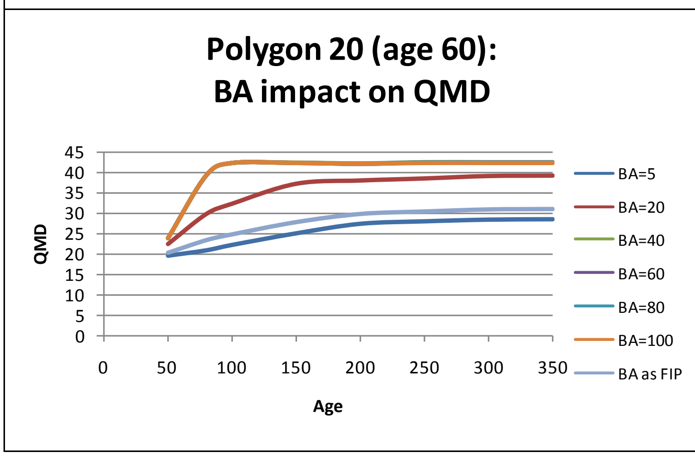


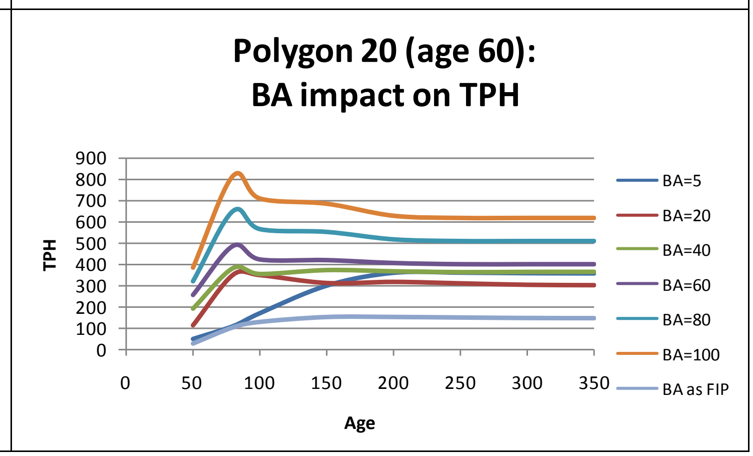





Polygon 19 (age 40):
BA impact on QMD
QMD
Age
0
50
100
150
200
250
300
350
0
5
10
15
20
25
30
35
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

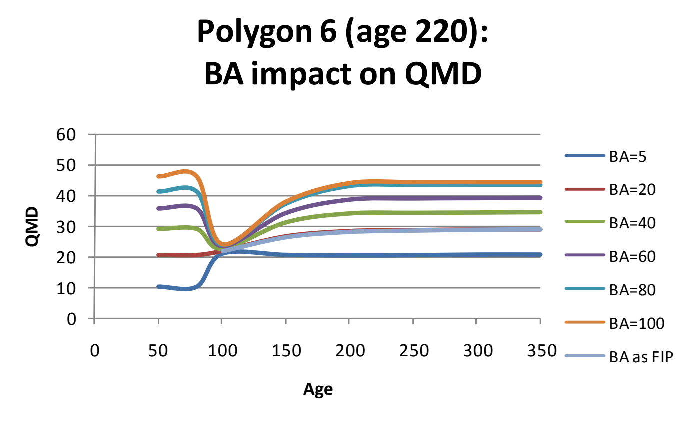

Polygon 19 (age 40):
BA impact on TPH
TPH
Age
0
50
100
150
200
250
300
350
0
500
1000
1500
2000
2500
3000
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

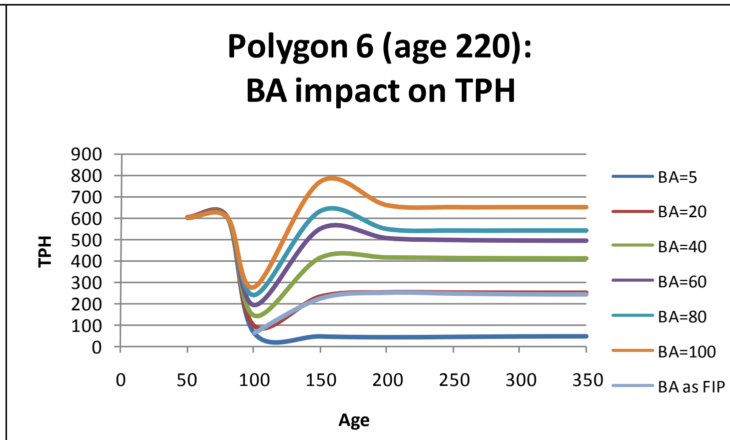

Polygon 20 (age 60):
BA impact on QMD
QMD
Age
0
50
100
150
200
250
300
350
0
5
10
15
20
25
30
35
40
45
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

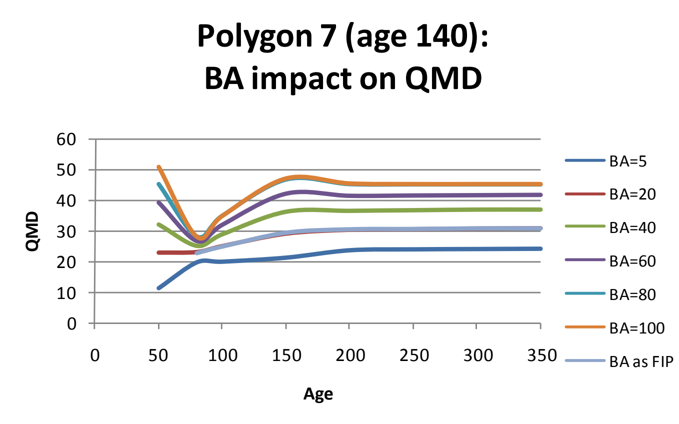

Polygon 20 (age 60):
BA impact on TPH
TPH
Age
0
50
100
150
200
250
300
350
0
100
200
300
400
500
600
700
800
900
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

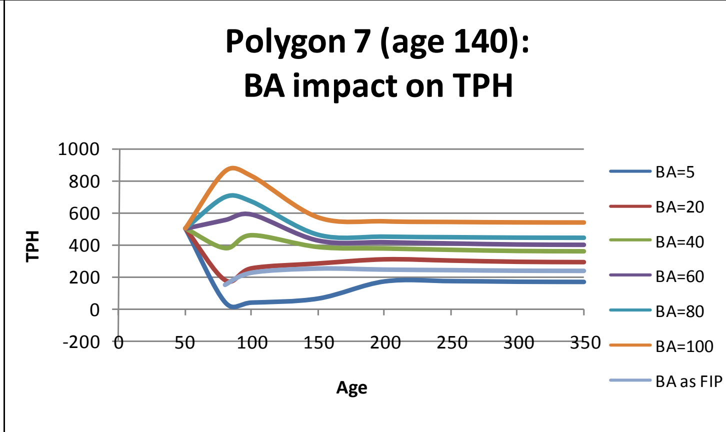
Appendix G_3: Effect of basal area change on QMD and TPH over time

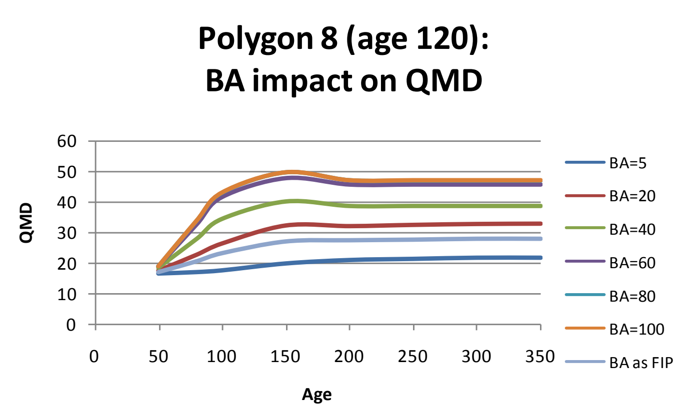
Polygons 81 to 249 years of age at reference year

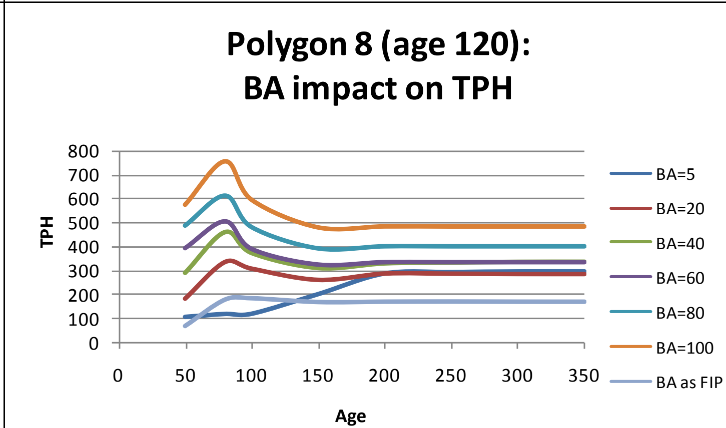


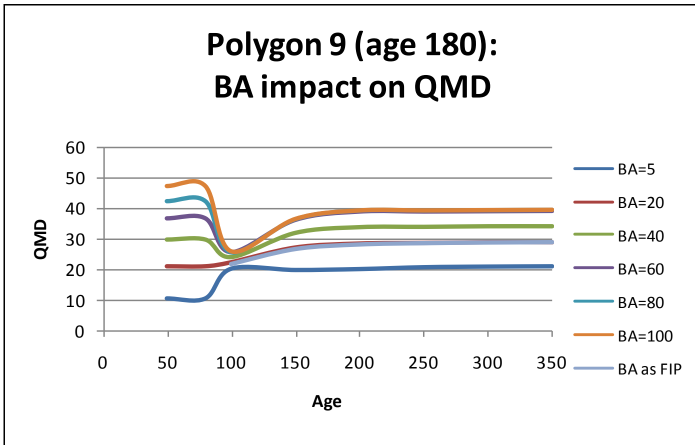


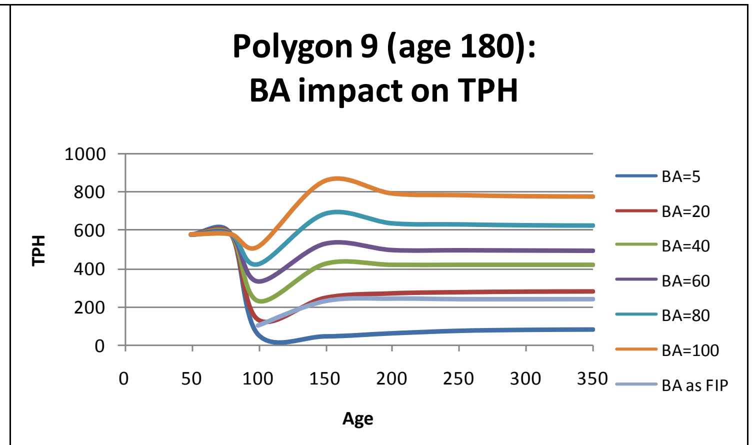


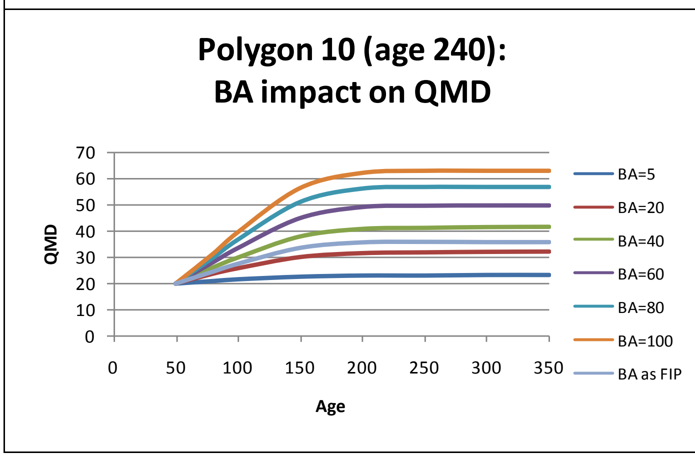


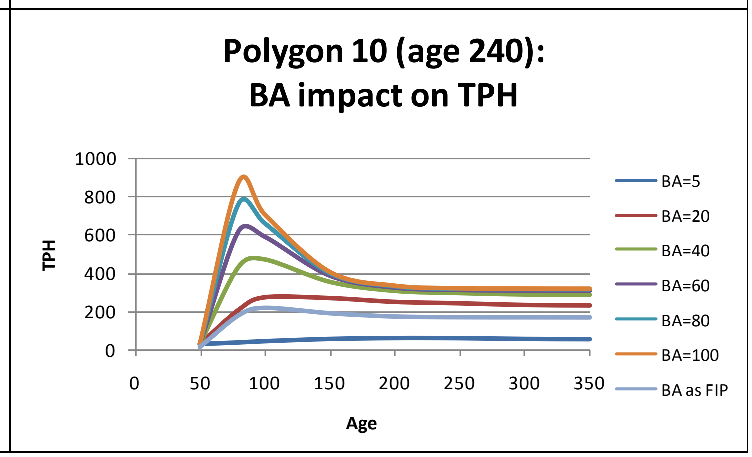





Polygon 9 (age 180):
BA impact on QMD
QMD
60
50
40
30
20
10
0
0
50
100
150
200
250
300
350
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

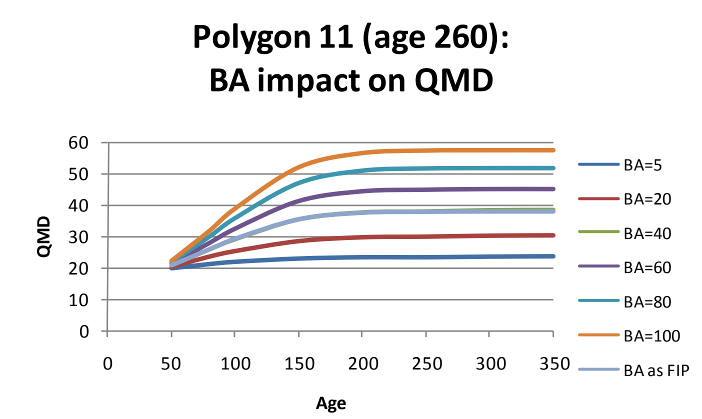

Polygon 9 (age 180):
BA impact on TPH
TPH
1000
800
600
400
200
0
0
50
100
150
200
250
300
350
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

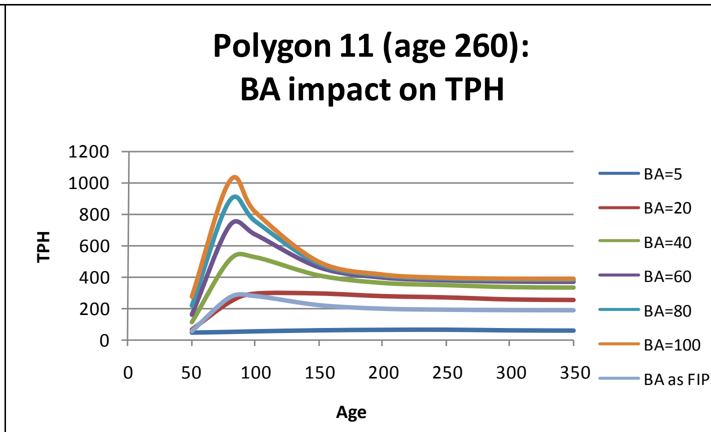

Polygon 10 (age 240):
BA impact on QMD
QMD
70
60
50
40
30
20
10
0
0
50
100
150
200
250
300
350
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

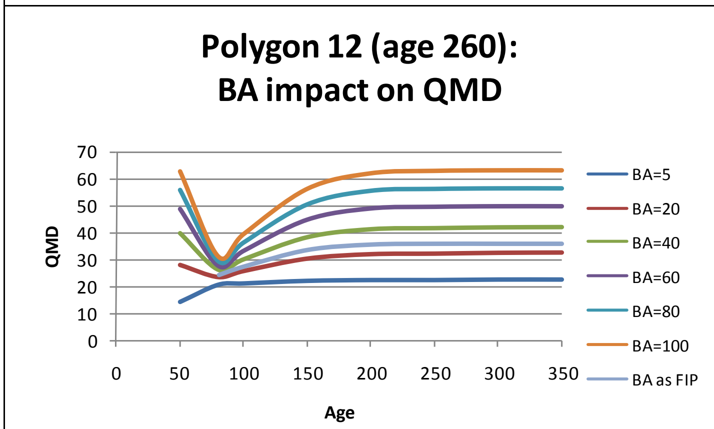

Polygon 10 (age 240):
BA impact on TPH
TPH
1000
800
600
400
200
0
0
50
100
150
200
250
300
350
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

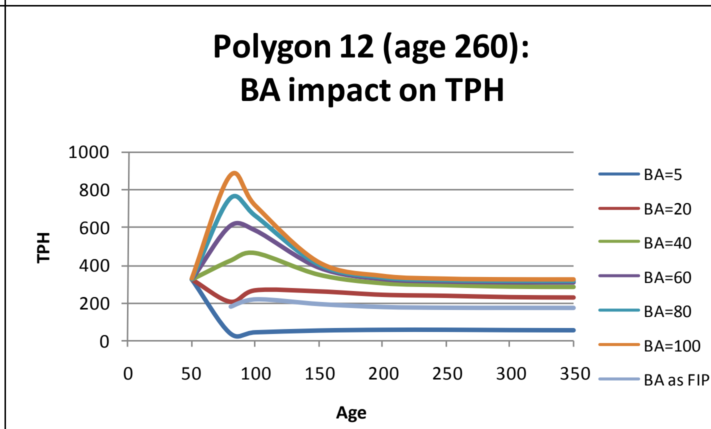
Appendix G_4: Effect of basal area change on QMD and TPH over time

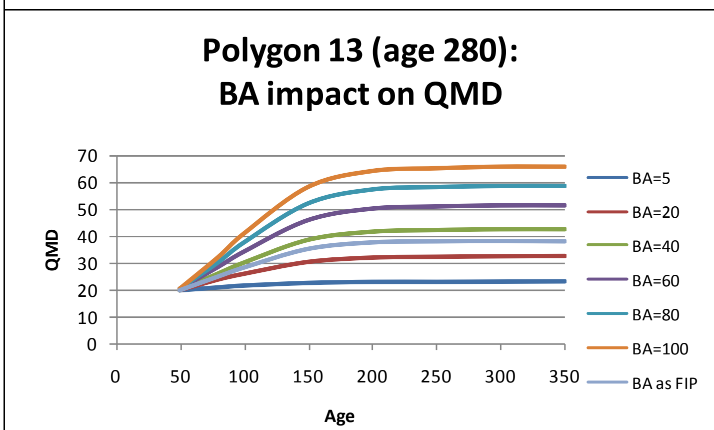
Polygons 250+ years of age at reference year

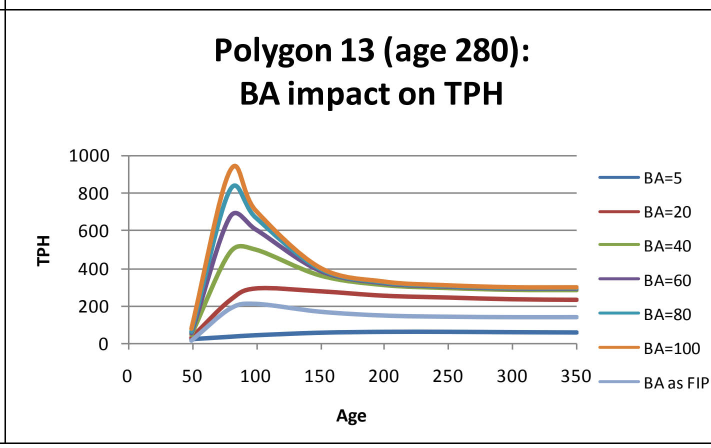


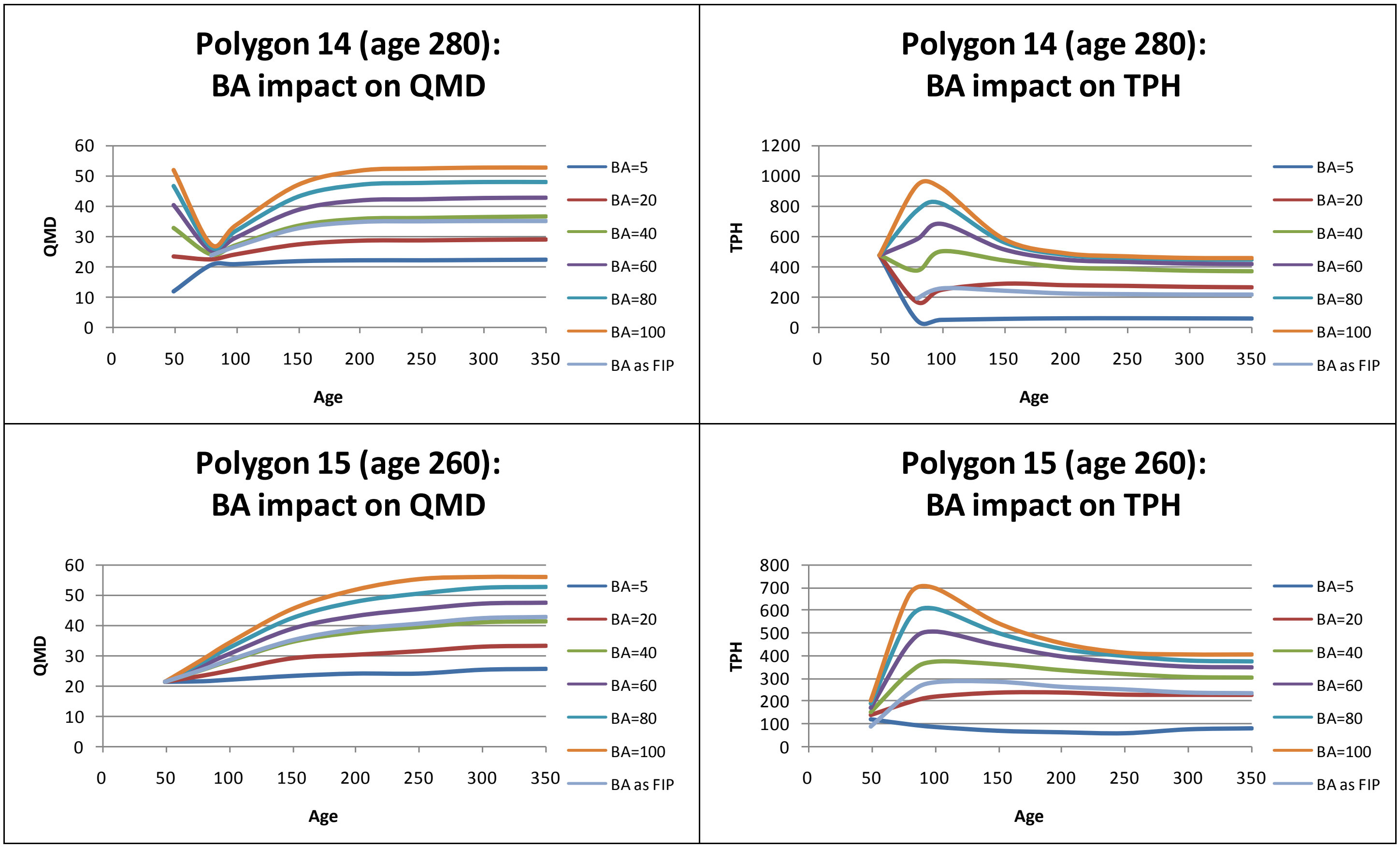






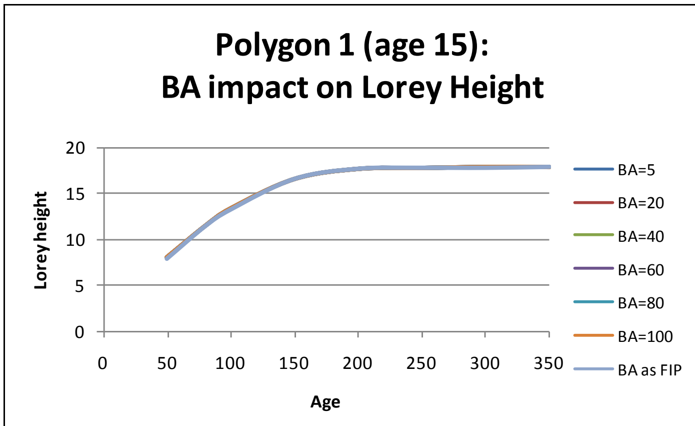


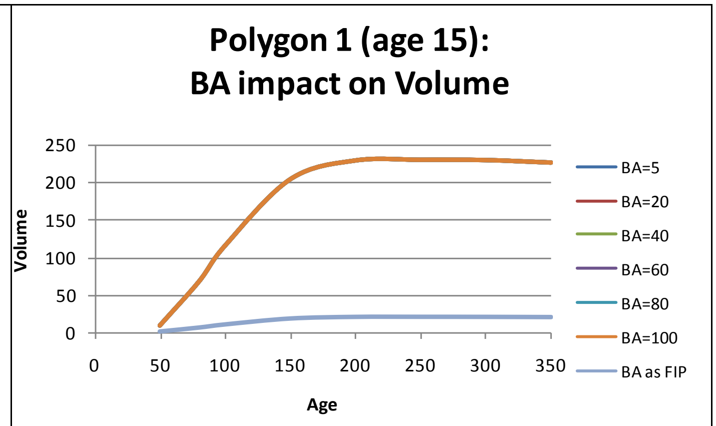


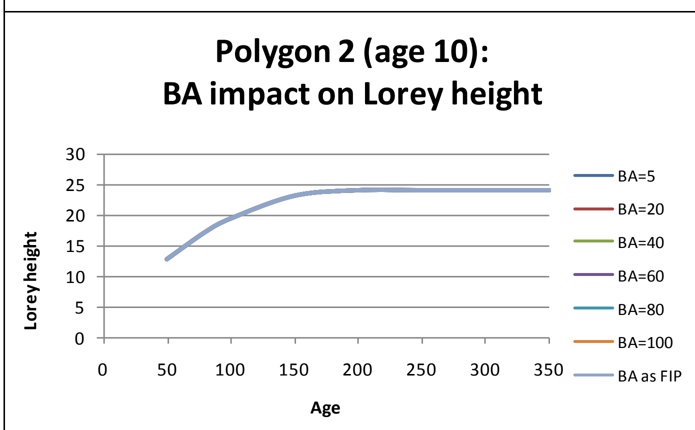

Polygon 14 (age 280):
BA impact on QMD
QMD
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP
Polygon 14 (age 280):
BA impact on TPH
TPH
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP
Polygon 15 (age 260):
BA impact on QMD
QMD
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP
Polygon 15 (age 260):
BA impact on TPH
TPH
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

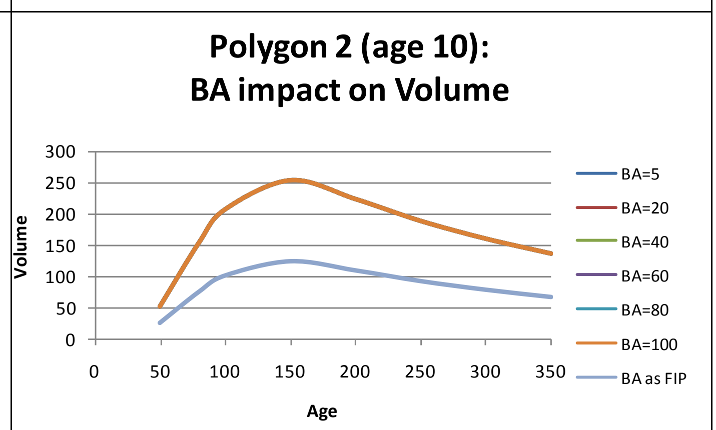
Appendix H_1: Effect of basal area change on Lorey height and volume over time

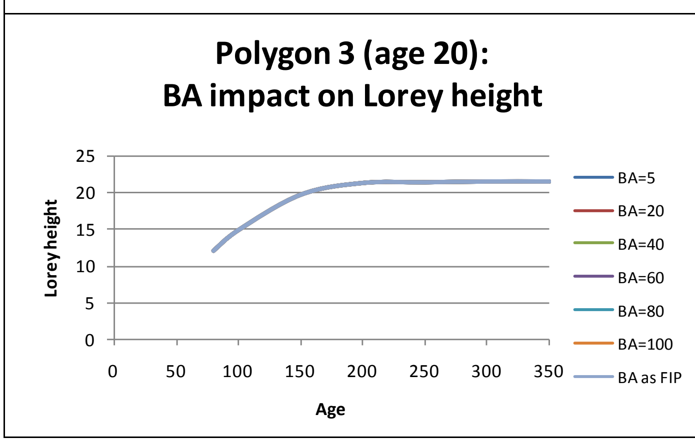
Polygons <30 years of age at reference year

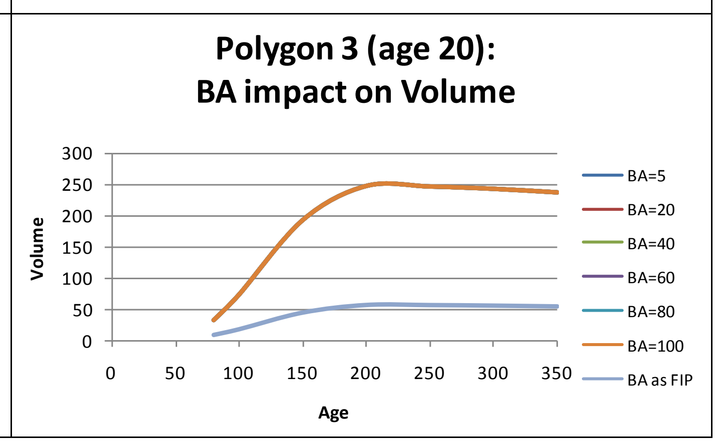


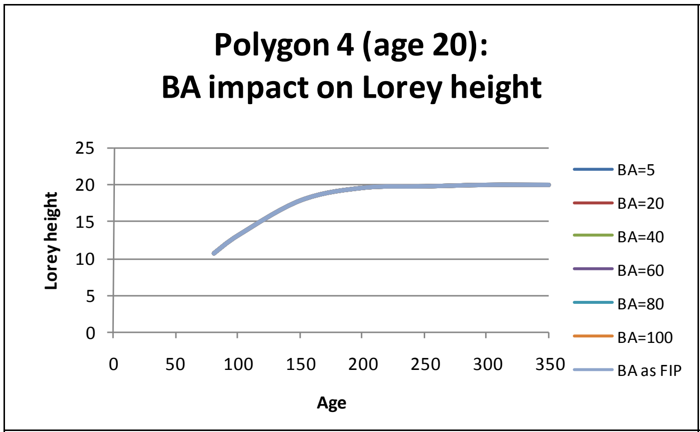


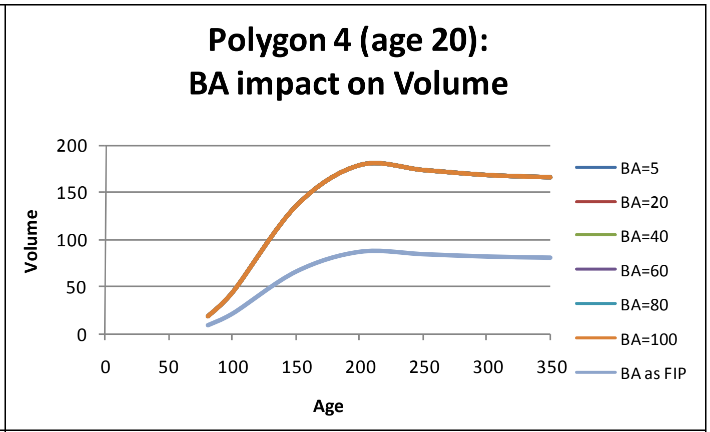


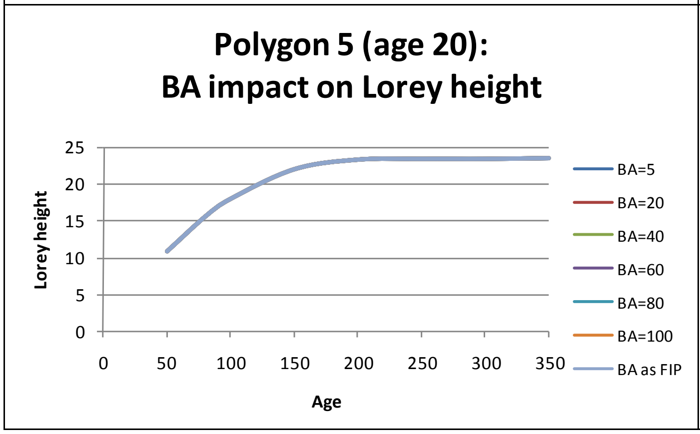


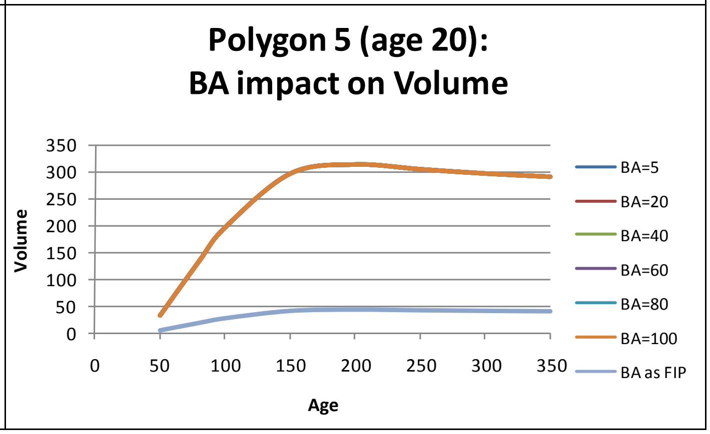





Polygon 4 (age 20):
BA impact on Lorey height
Lorey height
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

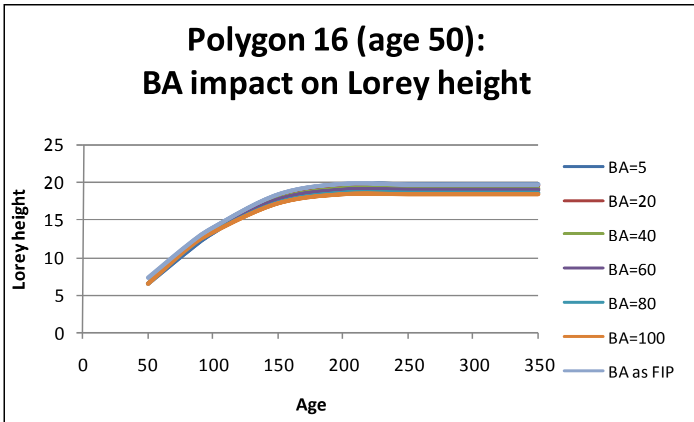

Polygon 4 (age 20):
BA impact on Volume
Volume
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

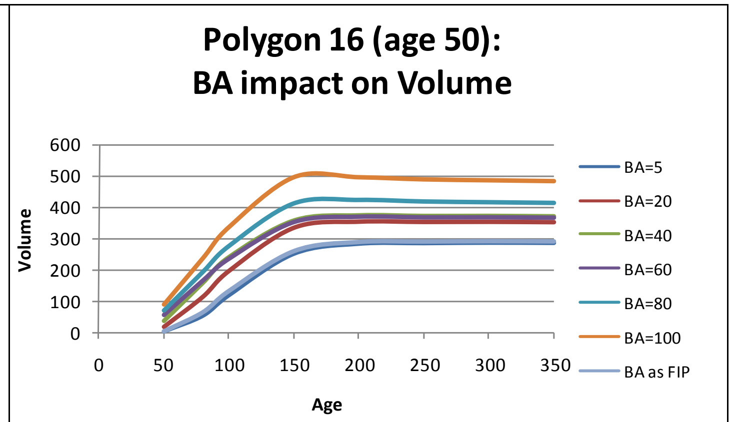

Polygon 5 (age 20):
BA impact on Lorey height
Lorey height
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

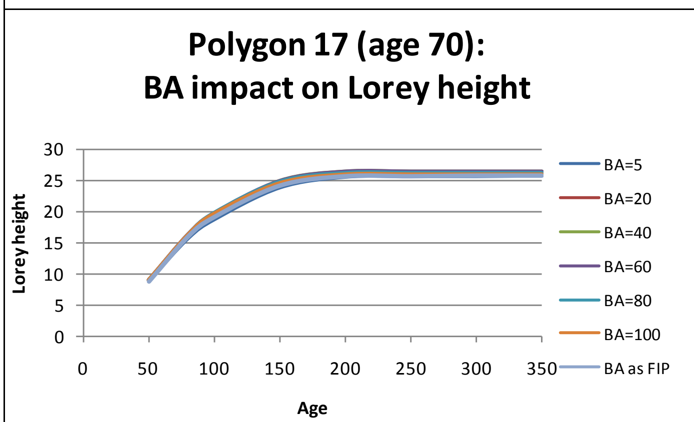

Polygon 5 (age 20):
BA impact on Volume
Volume
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

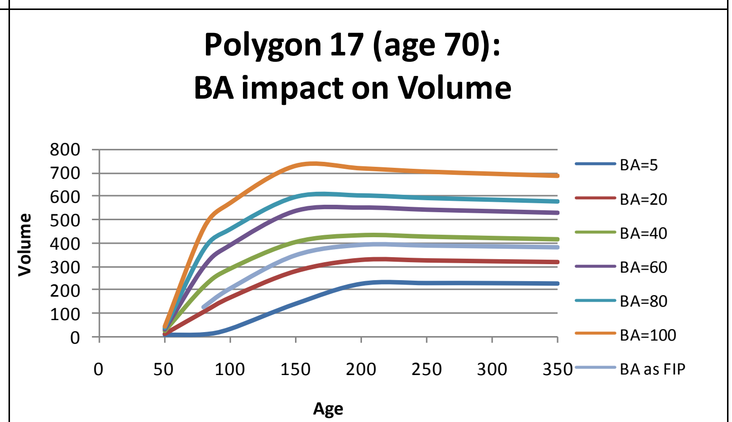
Appendix H_2: Effect of basal area change on Lorey height and volume over time

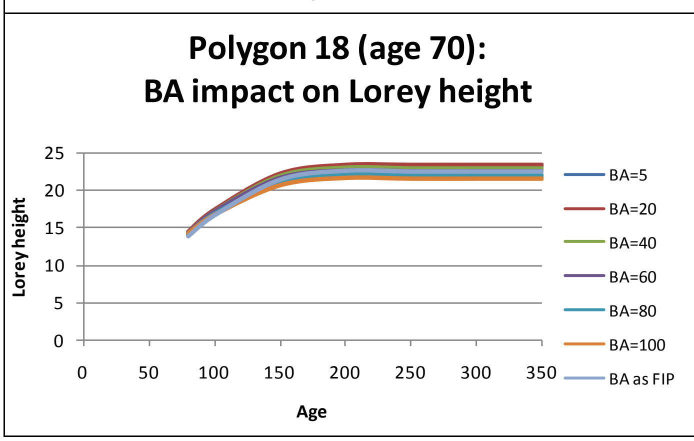
Polygons 30 to 80 years of age at reference year

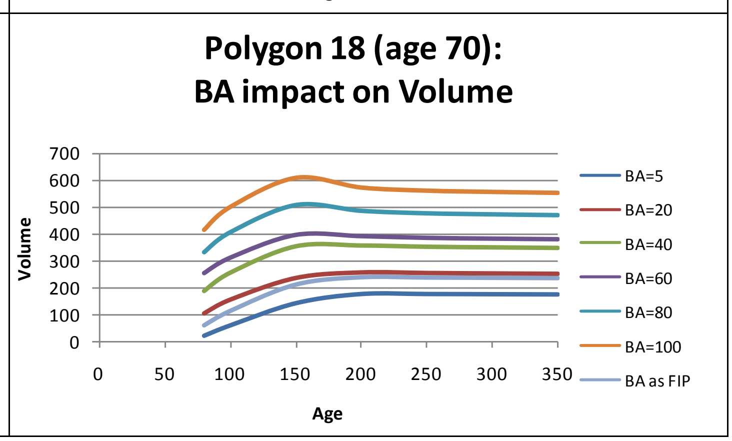


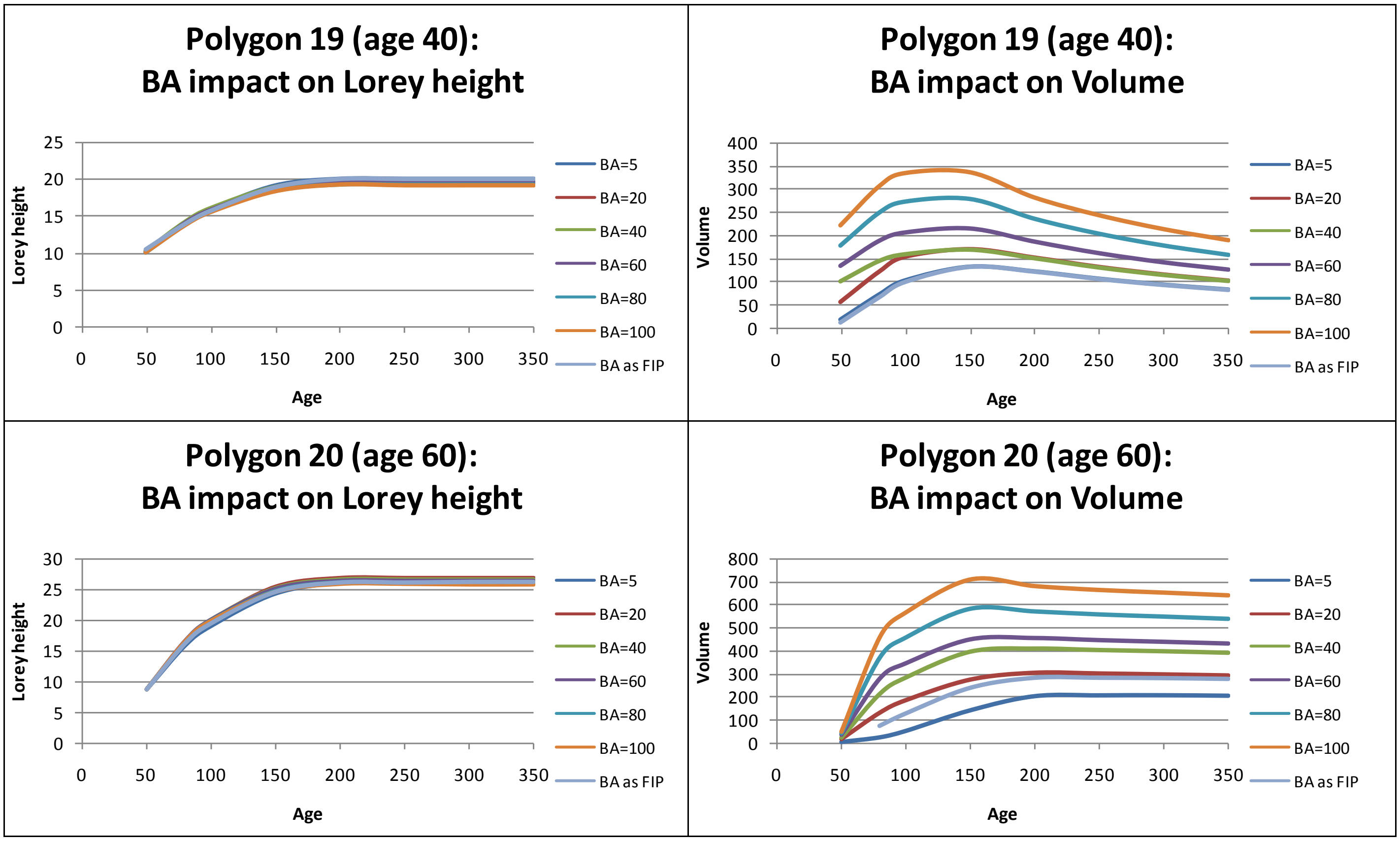






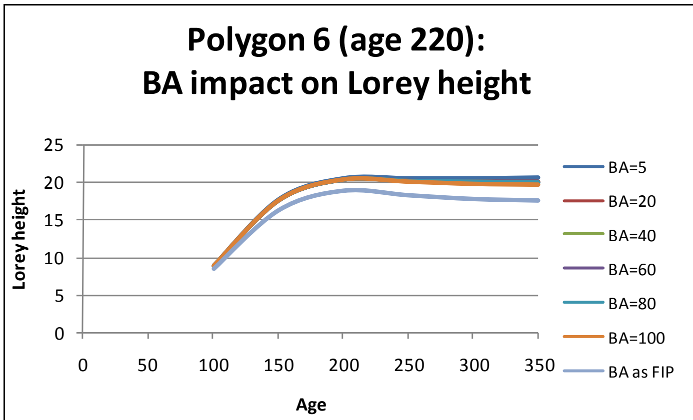


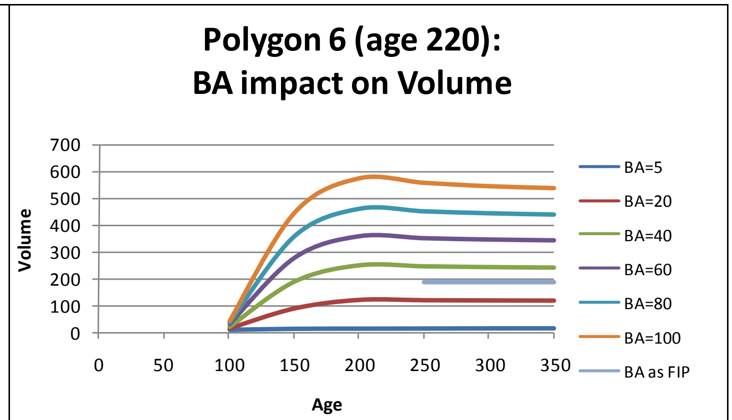


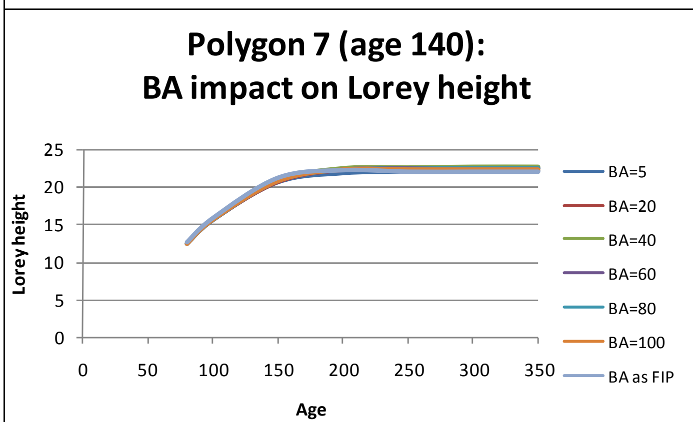

Polygon 19 (age 40):
BA impact on Lorey height
Lorey height
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP
Polygon 19 (age 40):
BA impact on Volume
Volume
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP
Polygon 20 (age 60):
BA impact on Lorey height
Lorey height
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP
Polygon 20 (age 60):
BA impact on Volume
Volume
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

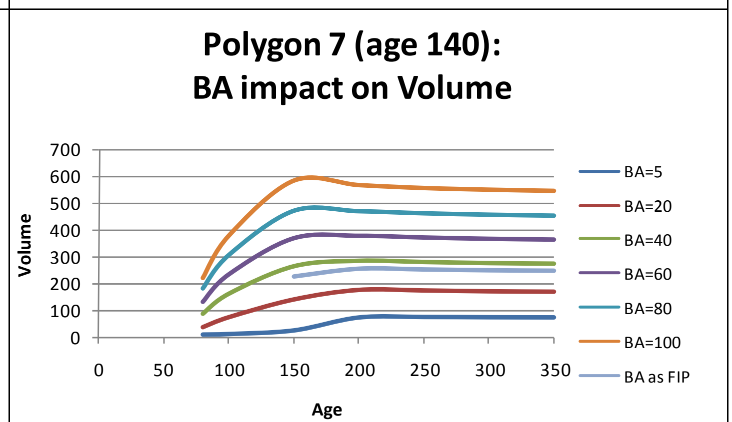
Appendix H_3: Effect of basal area change on Lorey height and volume over time

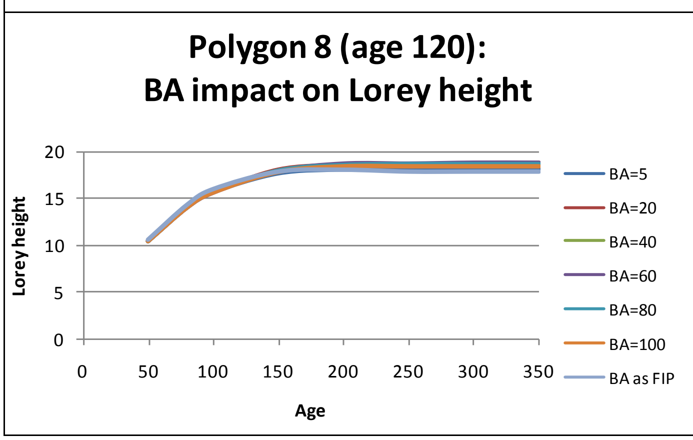
Polygons 81 to 249 years of age at reference year

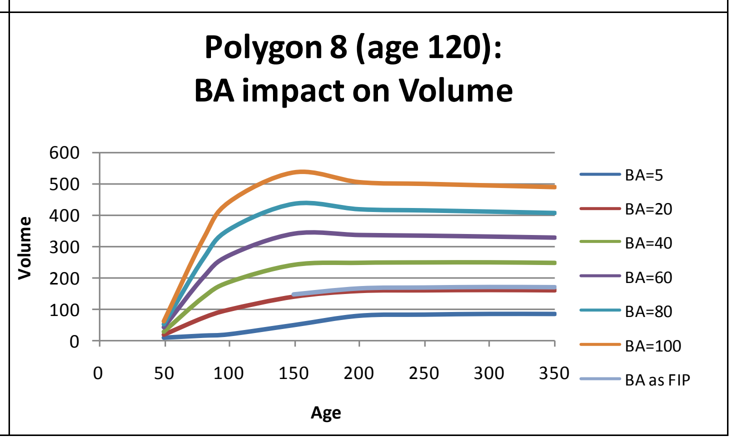


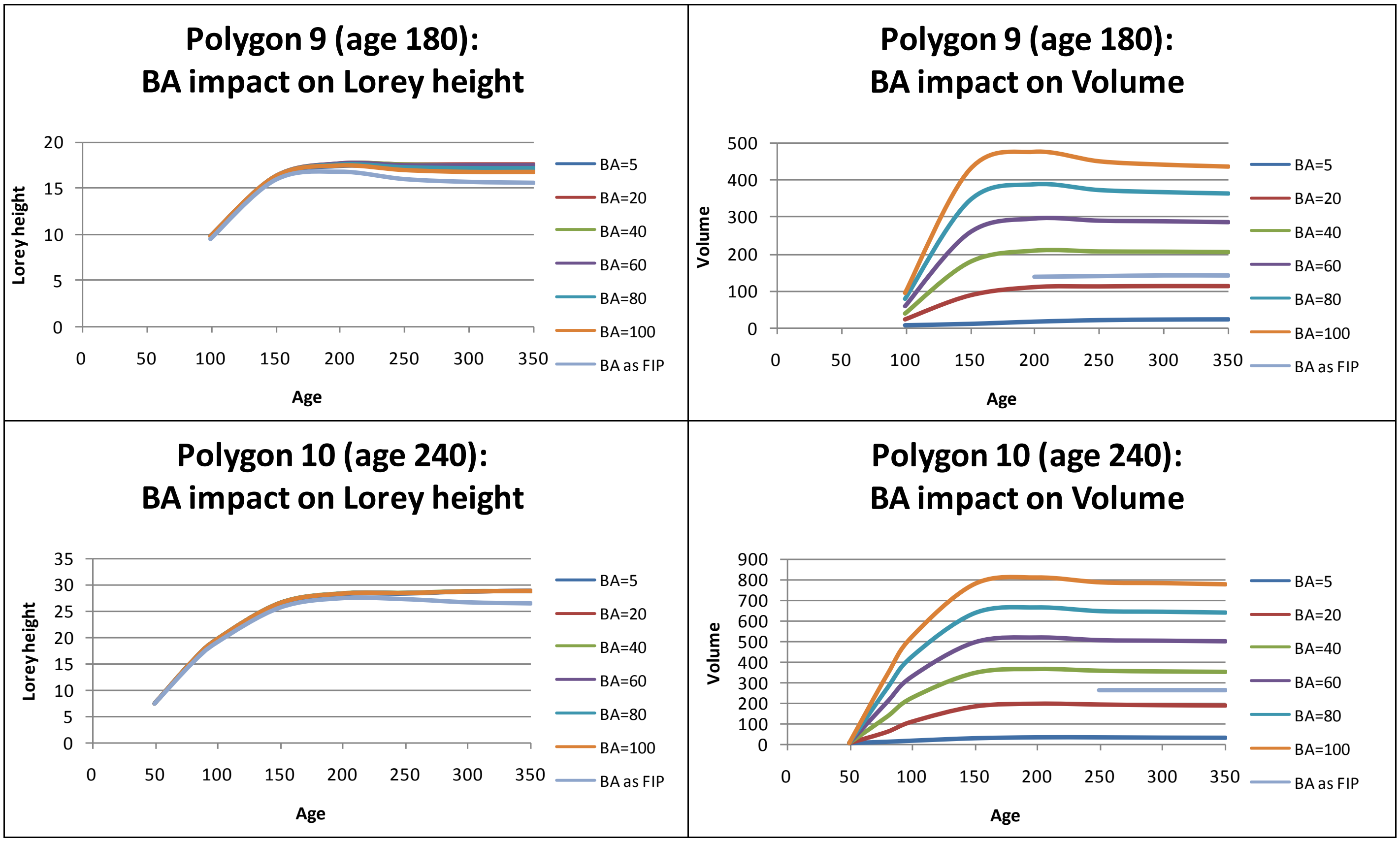






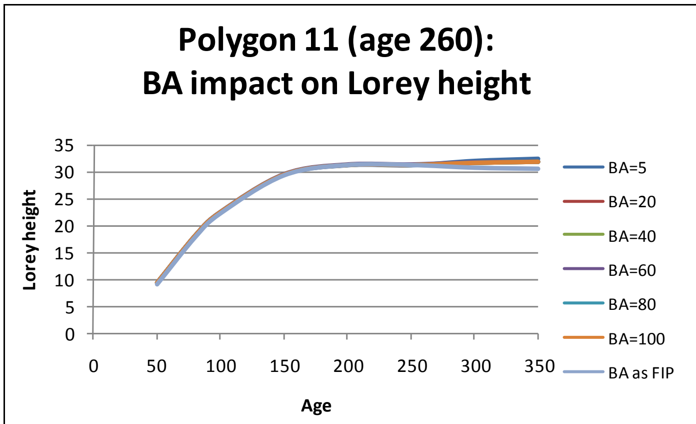


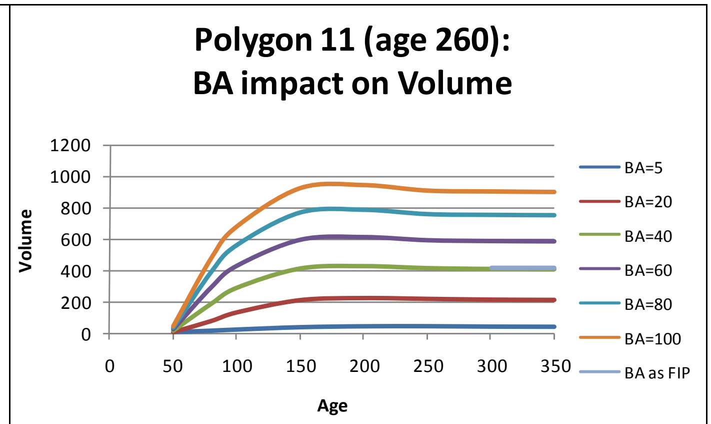


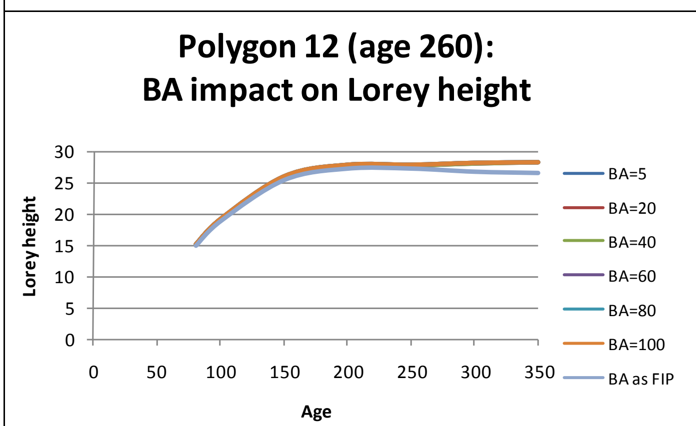

Polygon 9 (age 180):
BA impact on Lorey height
Lorey height
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP
Polygon 9 (age 180):
BA impact on Volume
Volume
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP
Polygon 10 (age 240):
BA impact on Lorey height
Lorey height
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP
Polygon 10 (age 240):
BA impact on Volume
Volume
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

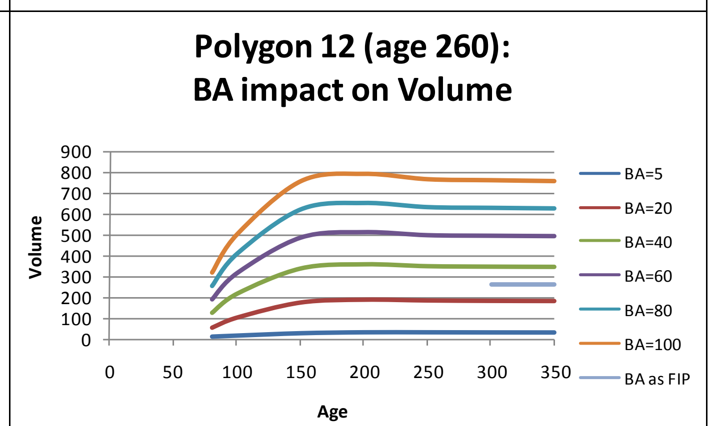
Appendix H_4: Effect of basal area change on Lorey height and volume over time

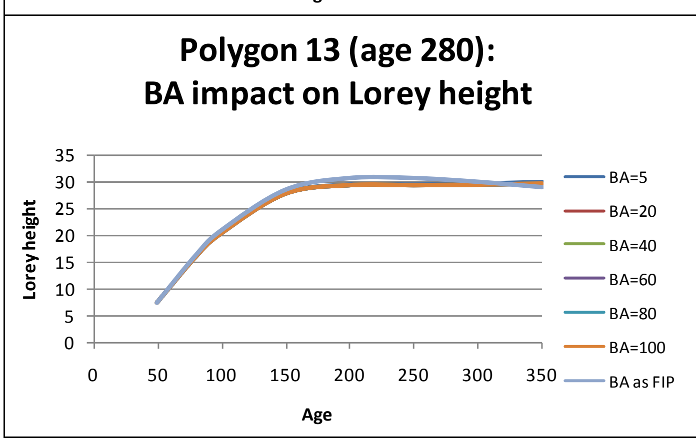
Polygons 250+ years of age at reference year

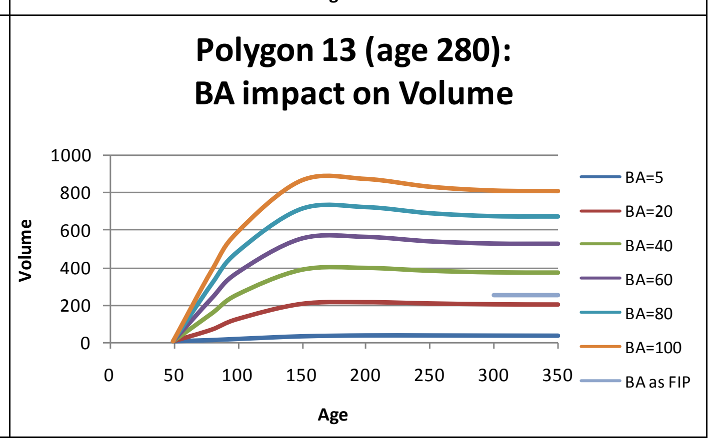


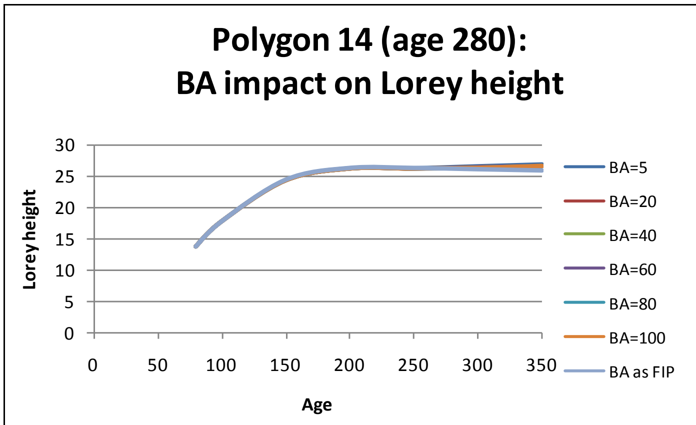


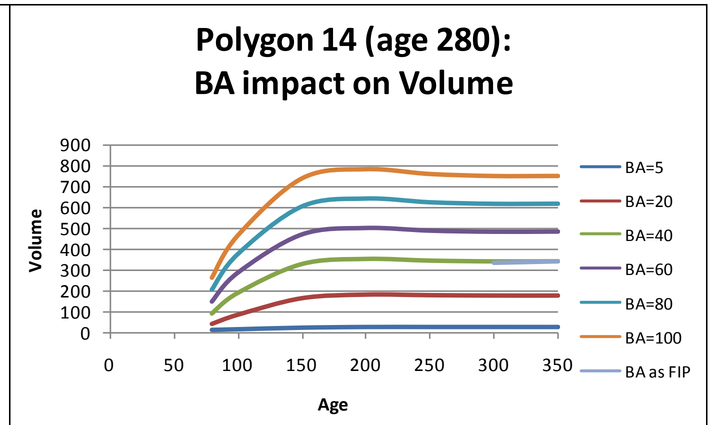


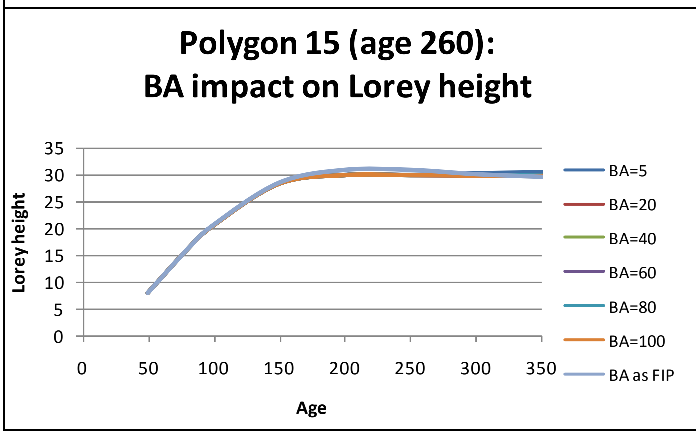


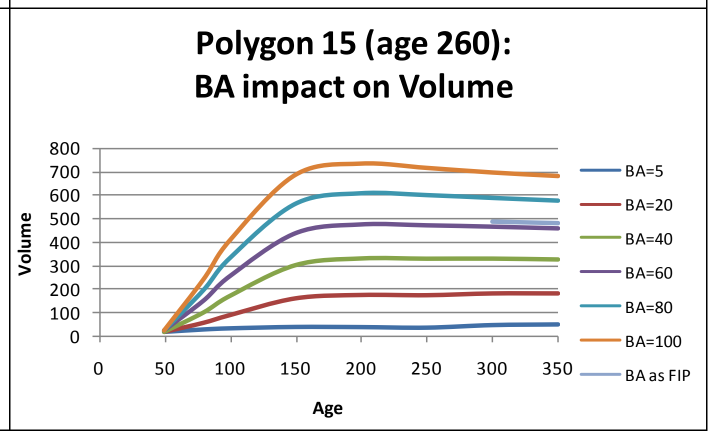





Polygon 14 (age 280):
BA impact on Lorey height
Lorey height
0 5 10 15 20 25 30
0 50 100 150 200 250 300 350
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

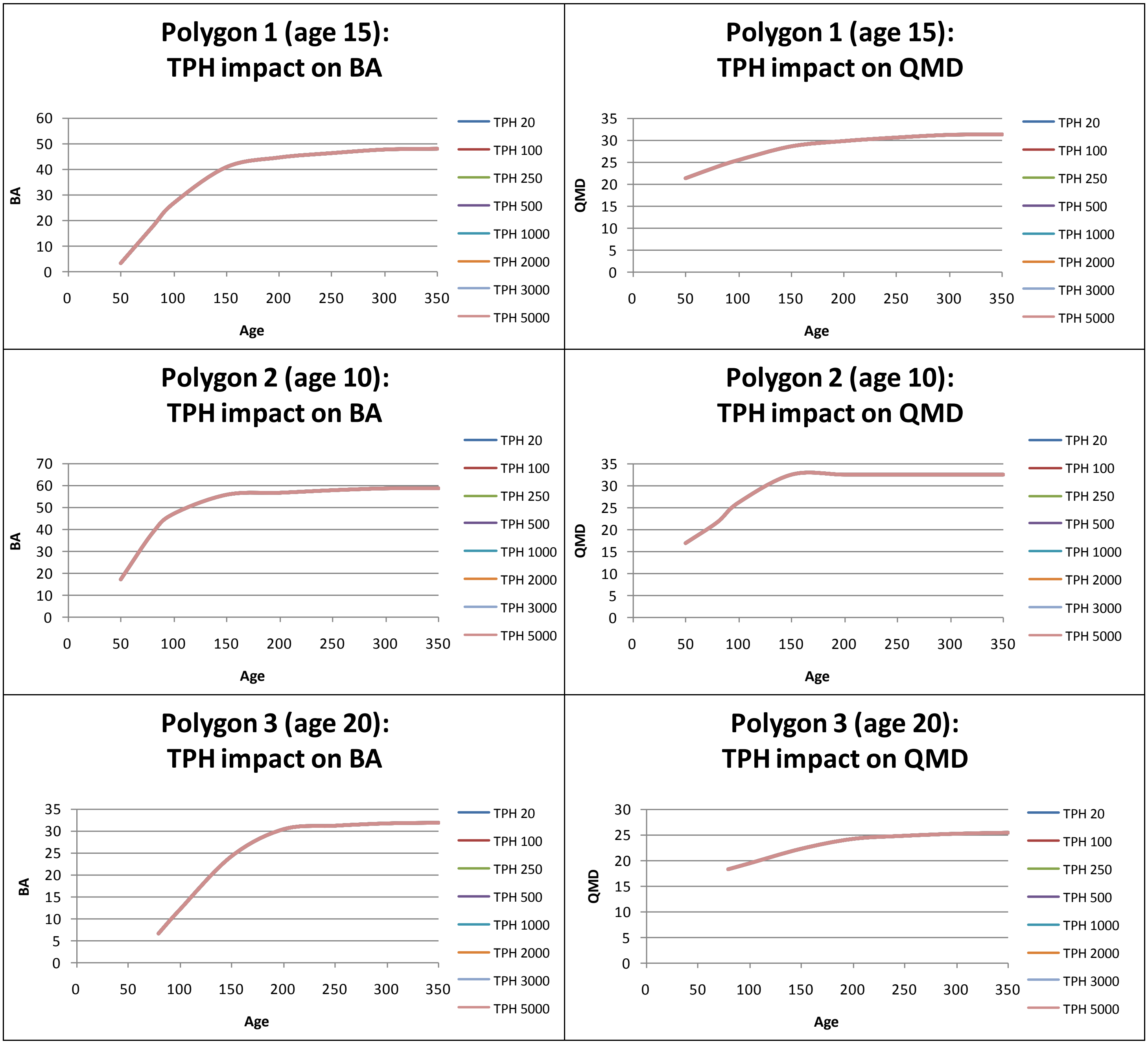

Polygon 14 (age 280):
BA impact on Volume
Volume
0 100 200 300 400 500 600 700 800 900
0 50 100 150 200 250 300 350
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

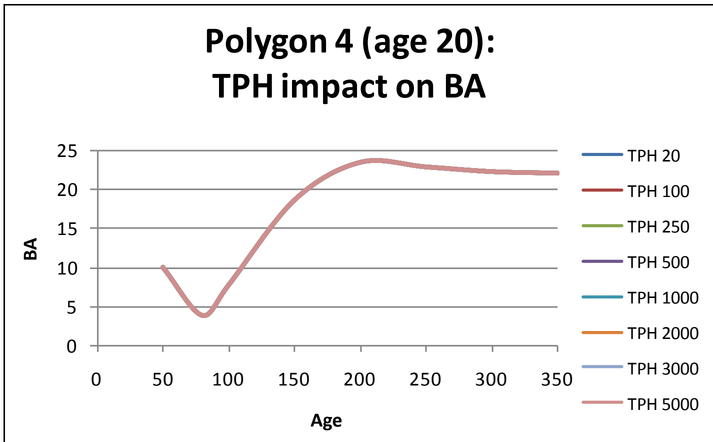

Polygon 15 (age 260):
BA impact on Lorey height
Lorey height
0 5 10 15 20 25 30 35
0 50 100 150 200 250 300 350
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

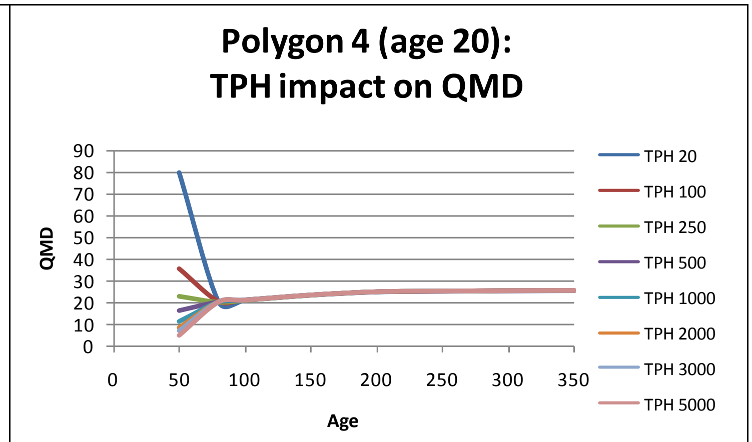

Polygon 15 (age 260):
BA impact on Volume
Volume
0 100 200 300 400 500 600 700 800
0 50 100 150 200 250 300 350
Age
BA=5
BA=20
BA=40
BA=60
BA=80
BA=100
BA as FIP

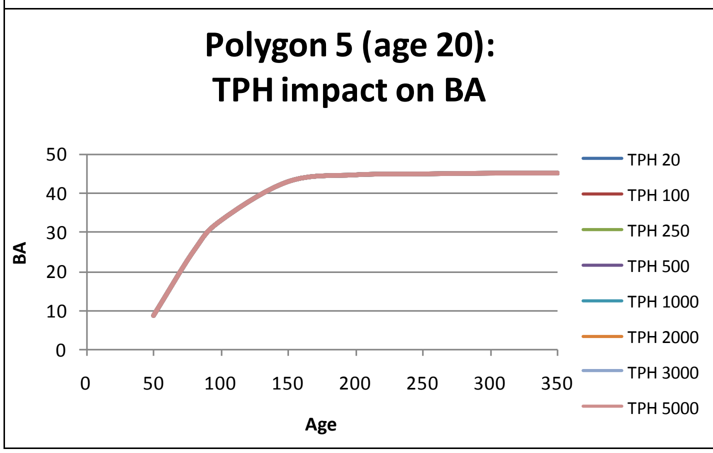
Appendix I_1: Effect of TPH change on BA and QMD over time

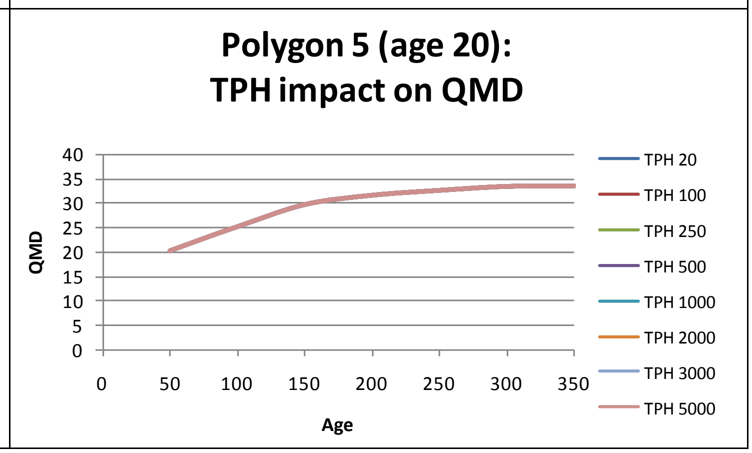
Polygons <30 years of age at reference year




Polygon 4 (age 20):
TPH impact on BA
BA
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

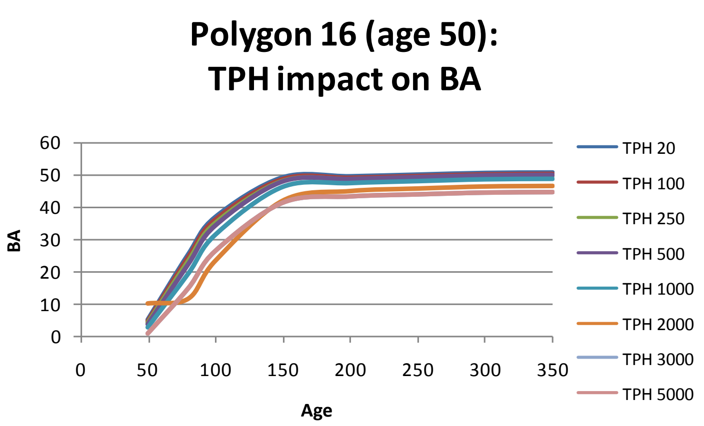

Polygon 4 (age 20):
TPH impact on QMD
QMD
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

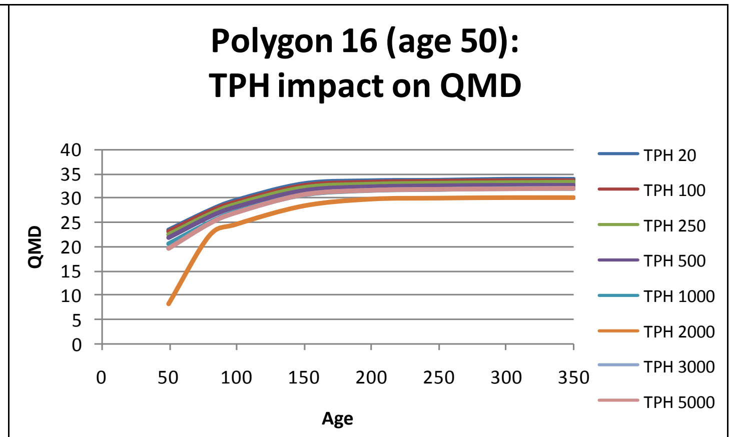

Polygon 5 (age 20):
TPH impact on BA
BA
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

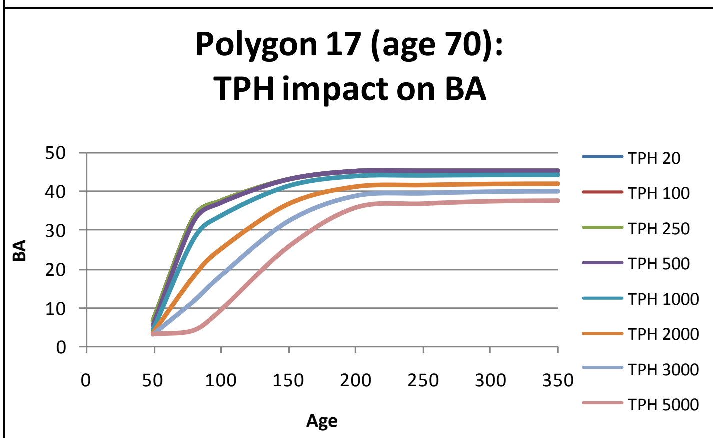

Polygon 5 (age 20):
TPH impact on QMD
QMD
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

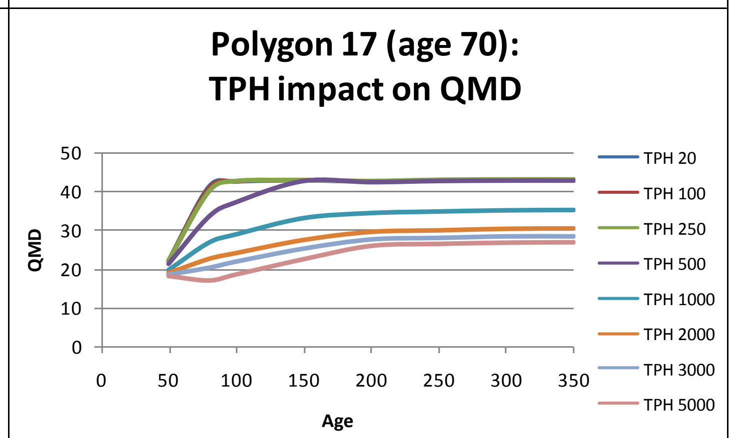
Appendix I_2: Effect of TPH change on BA and QMD over time

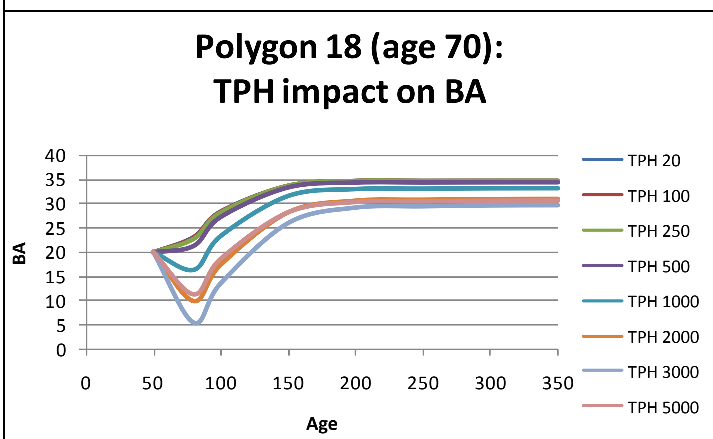
Polygons 30 to 80 years of age at reference year

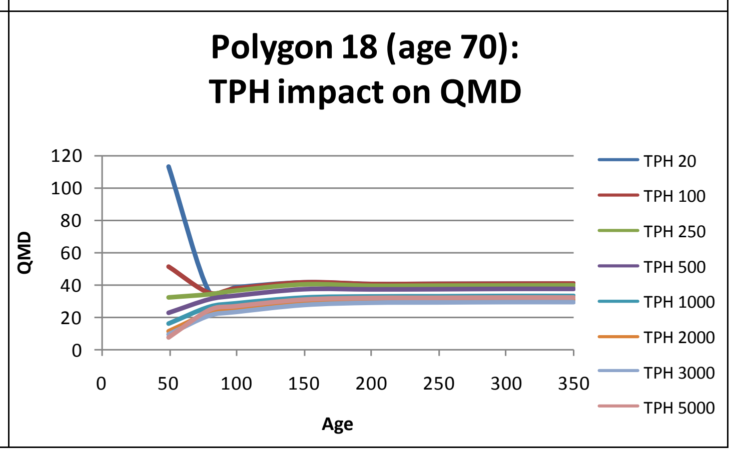


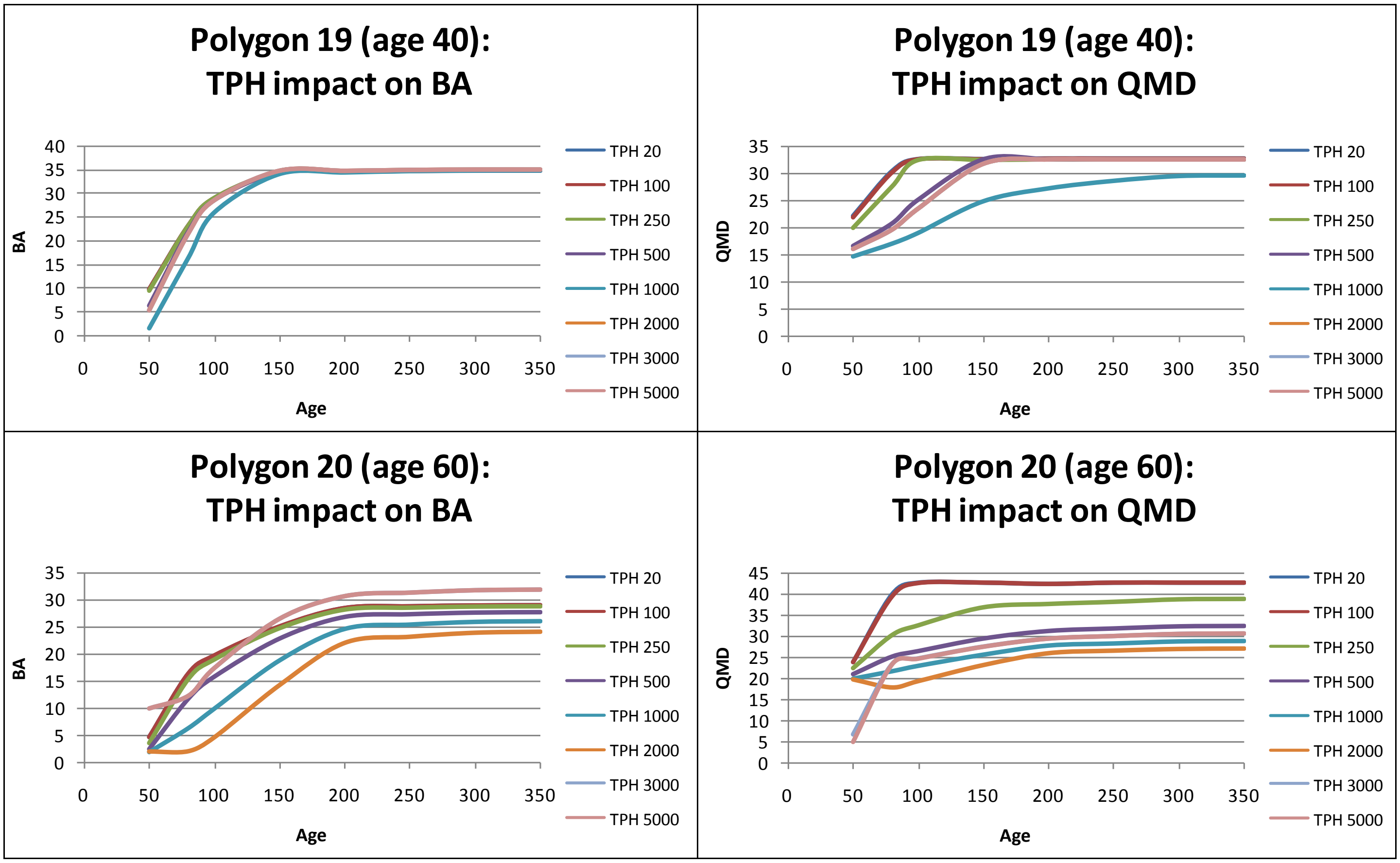








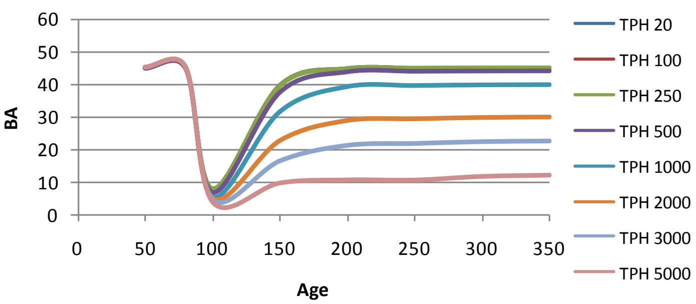



Polygon 19 (age 40):
TPH impact on BA
BA
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000
Polygon 19 (age 40):
TPH impact on QMD
QMD
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000
Polygon 20 (age 60):
TPH impact on BA
BA
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000
Polygon 20 (age 60):
TPH impact on QMD
QMD
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

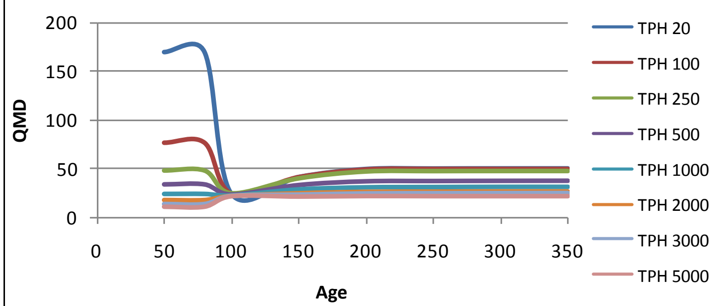
Appendix I_3: Effect of TPH change on BA and QMD over time

Polygons 81 to 249 years of age at reference year

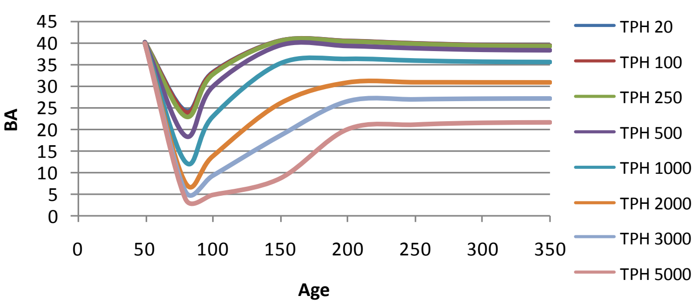
Polygon 6 (age 220): TPH impact on BA



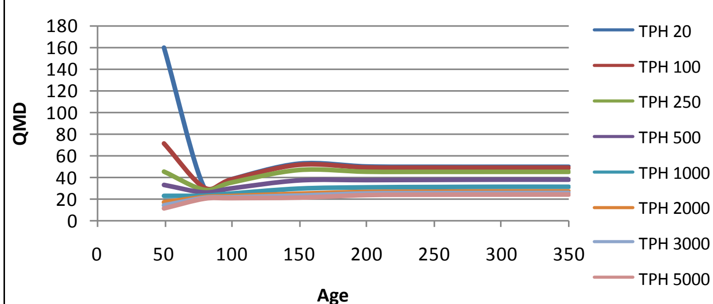
Polygon 6 (age 220): TPH impact on QMD



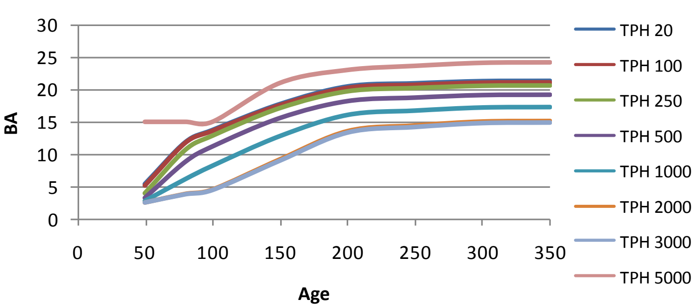
Polygon 7 (age 140): TPH impact on BA



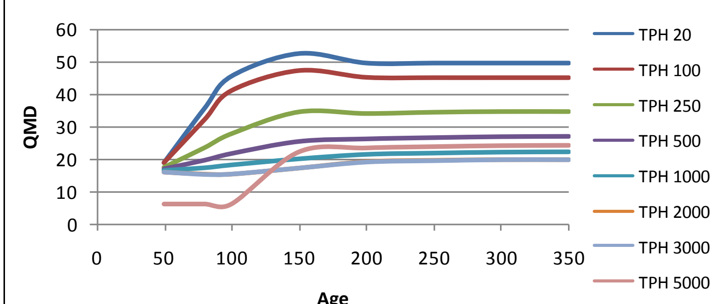
Polygon 7 (age 140): TPH impact on QMD

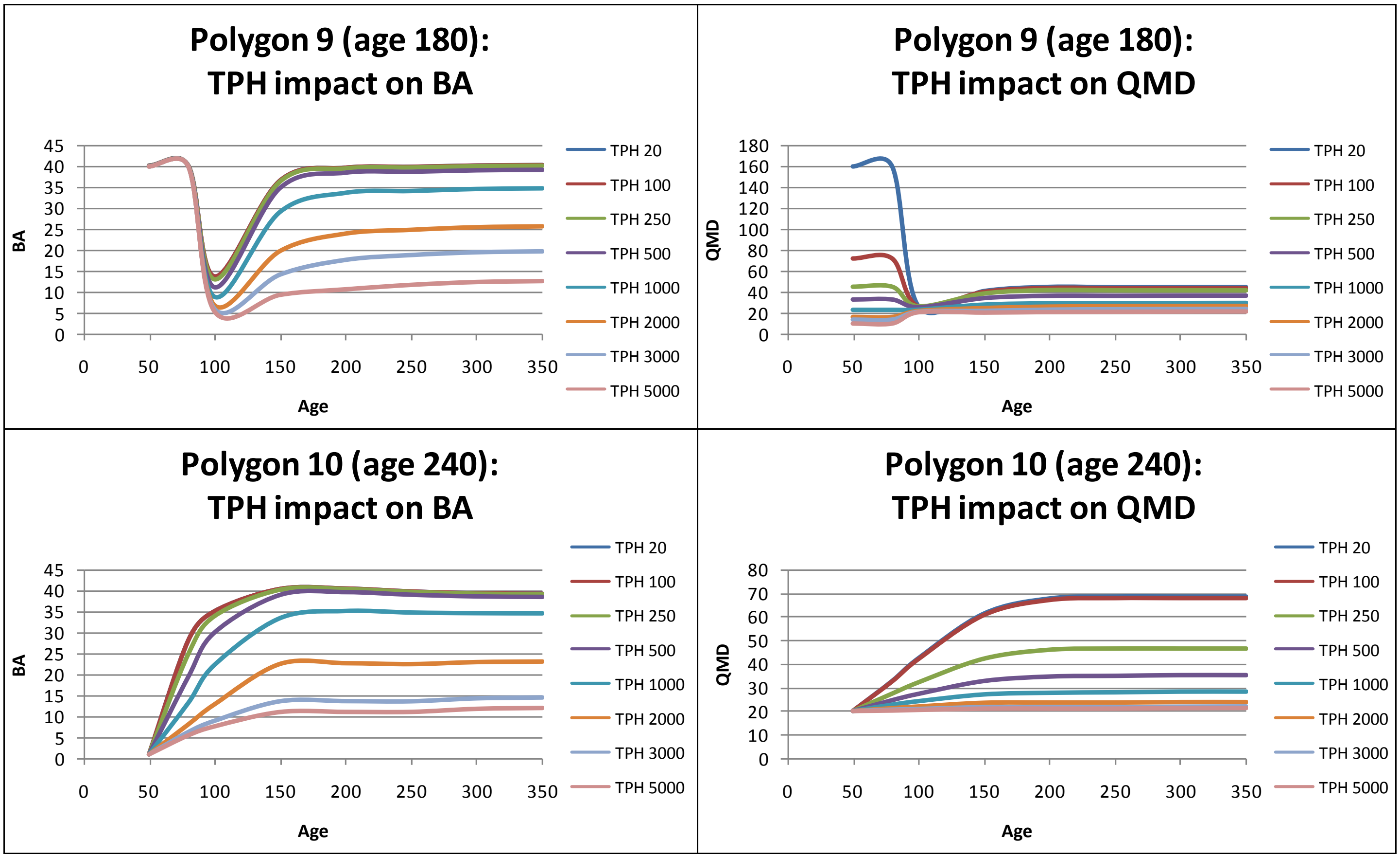


Polygon 8 (age 120): TPH impact on BA



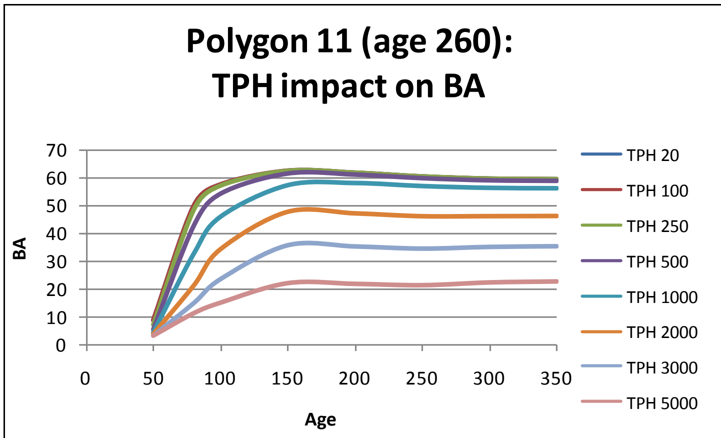
Polygon 8 (age 120): TPH impact on QMD

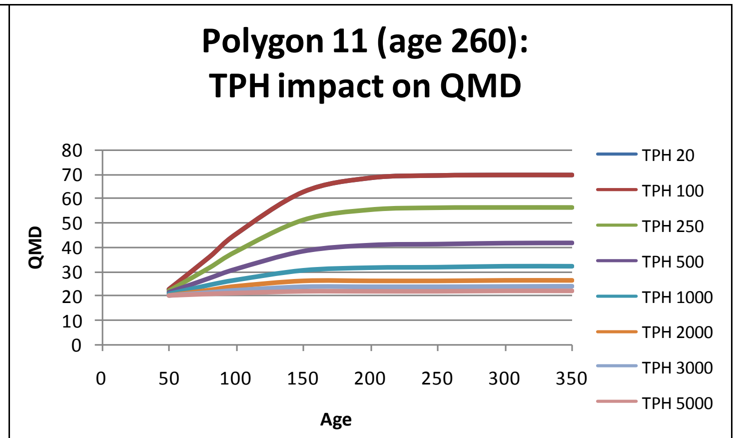


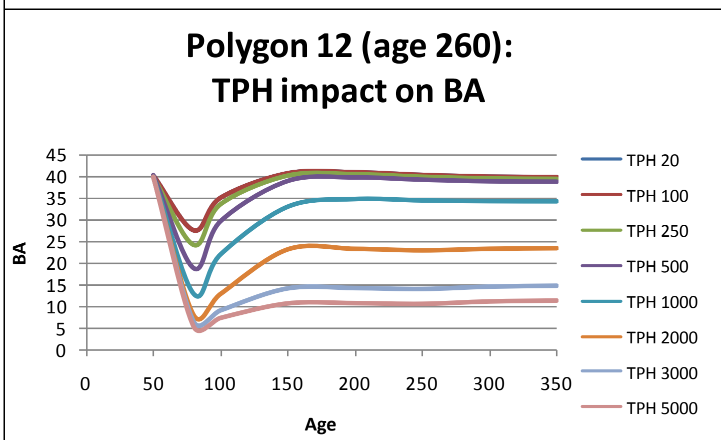

Polygon 9 (age 180):
TPH impact on BA
BA
Age
Polygon 9 (age 180):
TPH impact on QMD
QMD
Age
Polygon 10 (age 240):
TPH impact on BA
BA
Age
Polygon 10 (age 240):
TPH impact on QMD
QMD
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

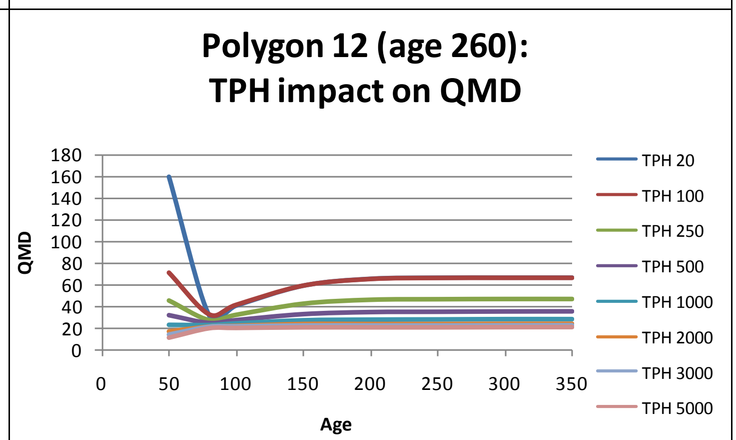
Appendix I_4: Effect of TPH change on BA and QMD over time

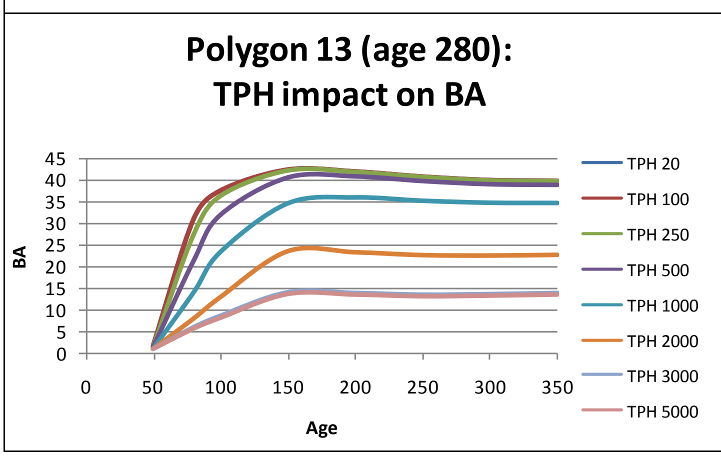
Polygons 250+ years of age at reference year

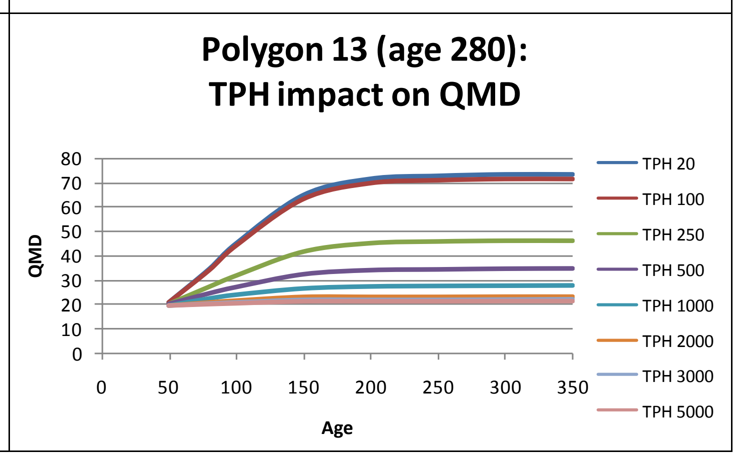


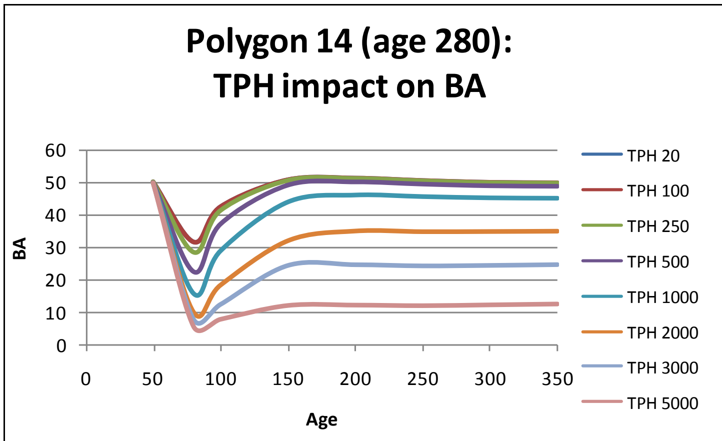


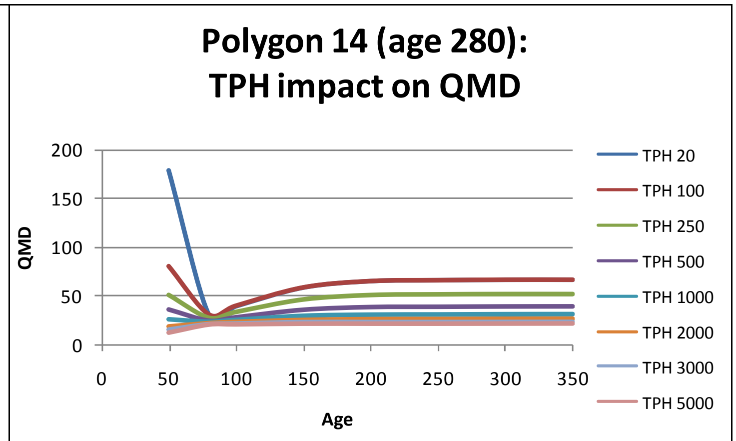


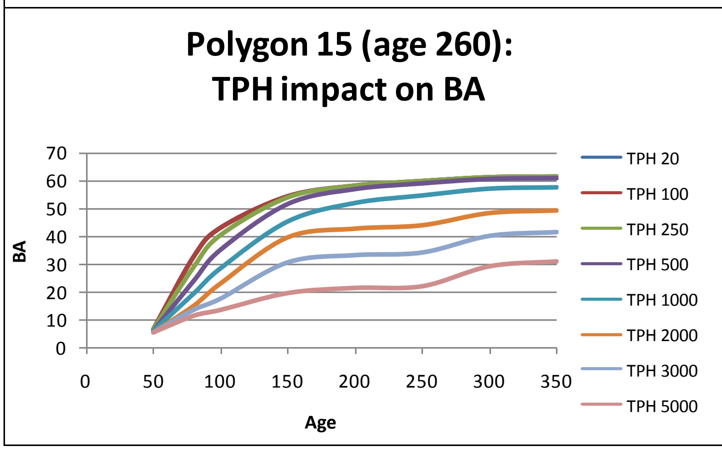


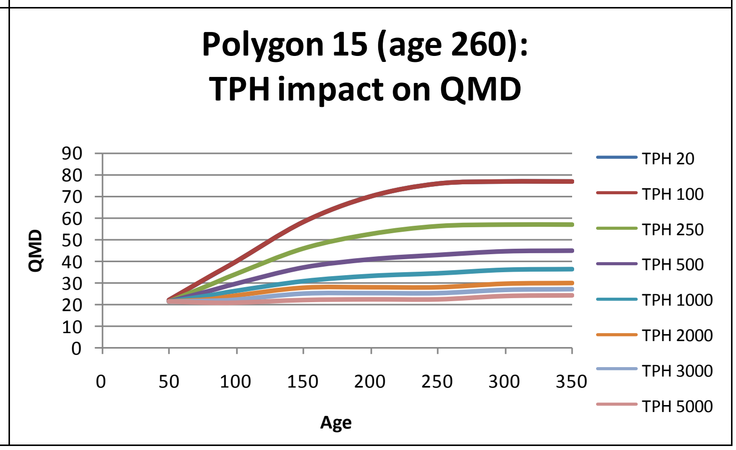





Polygon 14 (age 280):
TPH impact on BA
BA
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

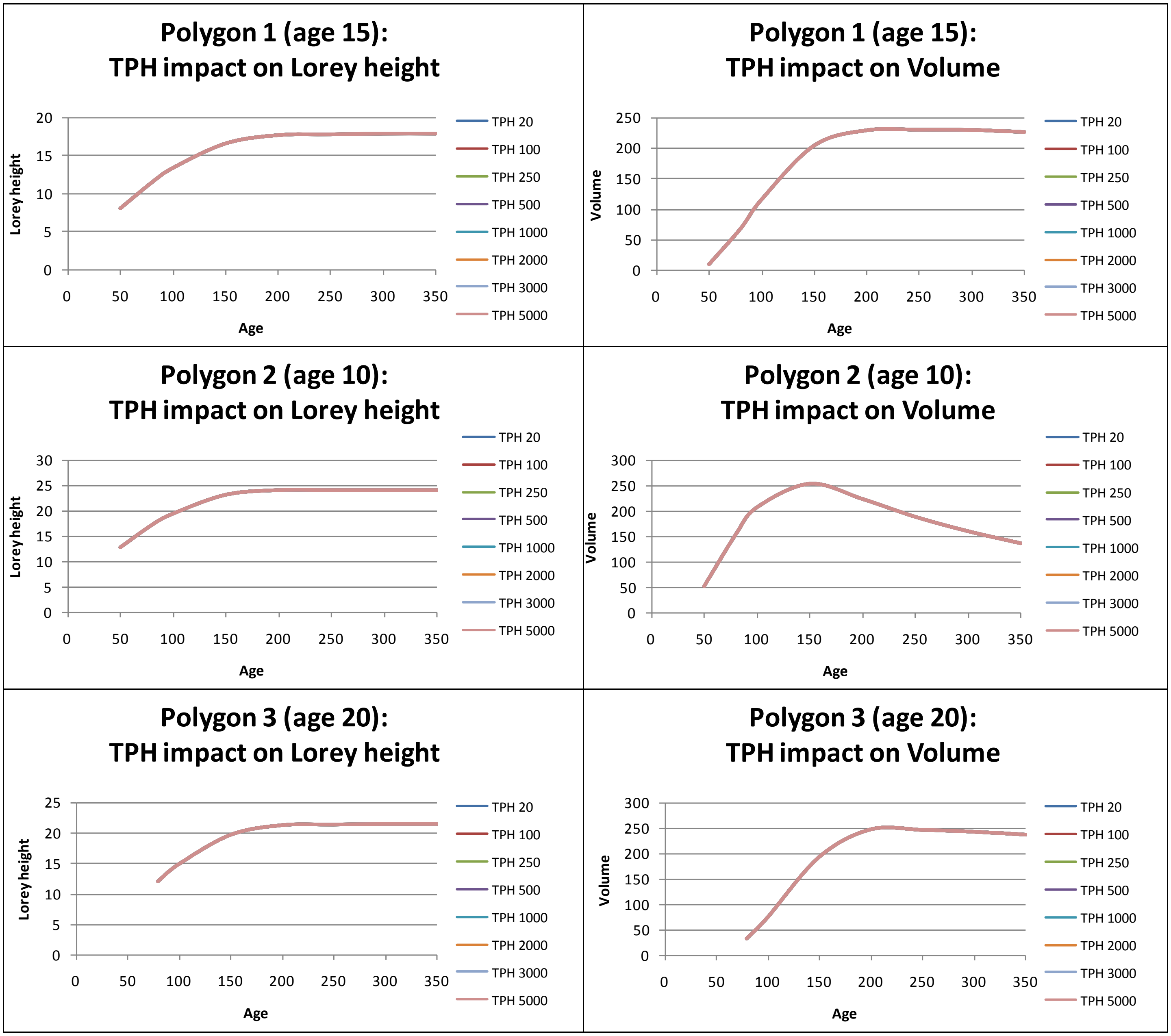

Polygon 14 (age 280):
TPH impact on QMD
QMD
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

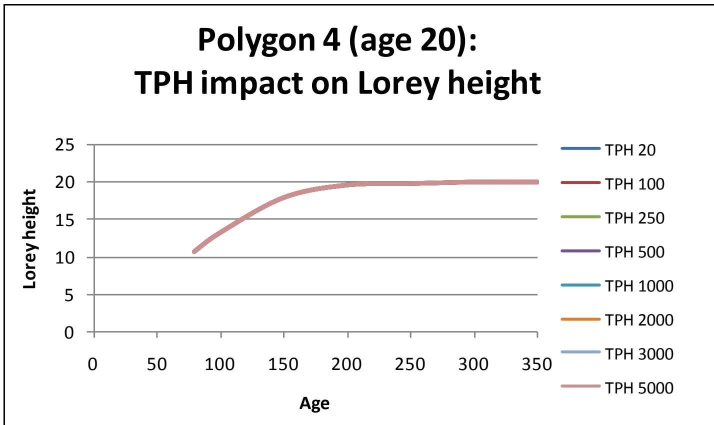

Polygon 15 (age 260):
TPH impact on BA
BA
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

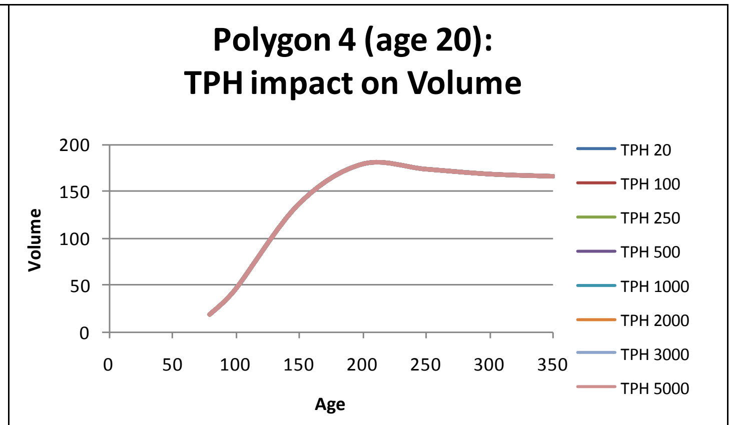

Polygon 15 (age 260):
TPH impact on QMD
QMD
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

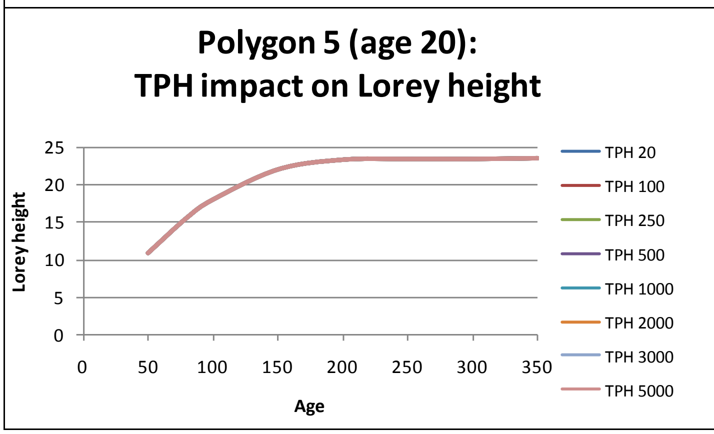
Appendix J_1: Effect of TPH change on Lorey height and volume over time

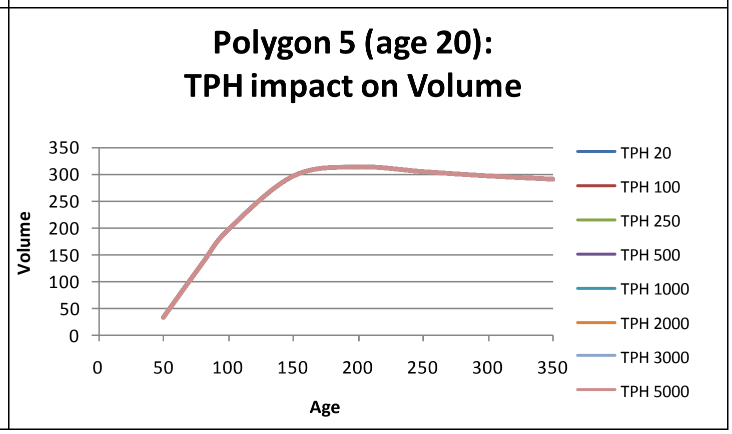
Polygons <30 years of age at reference year




Polygon 4 (age 20):
TPH impact on Lorey height
Lorey height
25
20
15
10
5
0
0
50
100
150
200
250
300
350
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

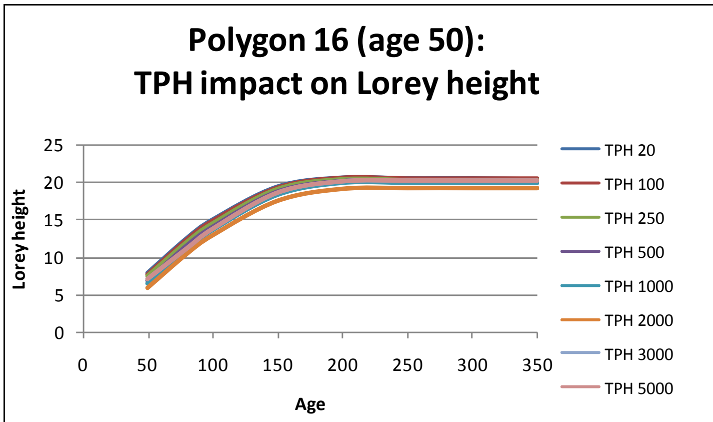

Polygon 4 (age 20):
TPH impact on Volume
Volume
200
150
100
50
0
0
50
100
150
200
250
300
350
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

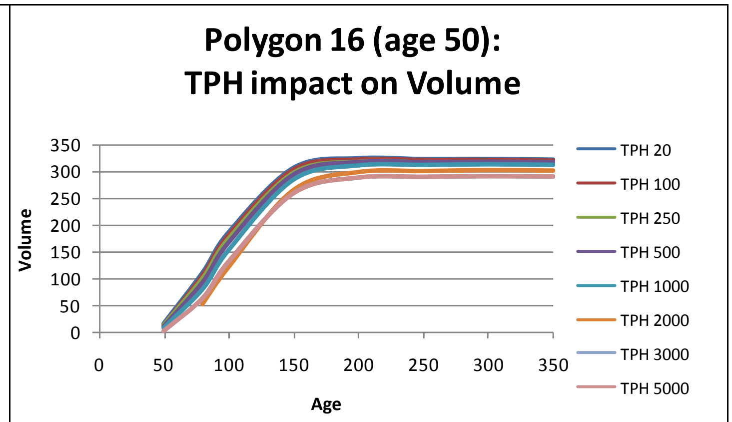

Polygon 5 (age 20):
TPH impact on Lorey height
Lorey height
25
20
15
10
5
0
0
50
100
150
200
250
300
350
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

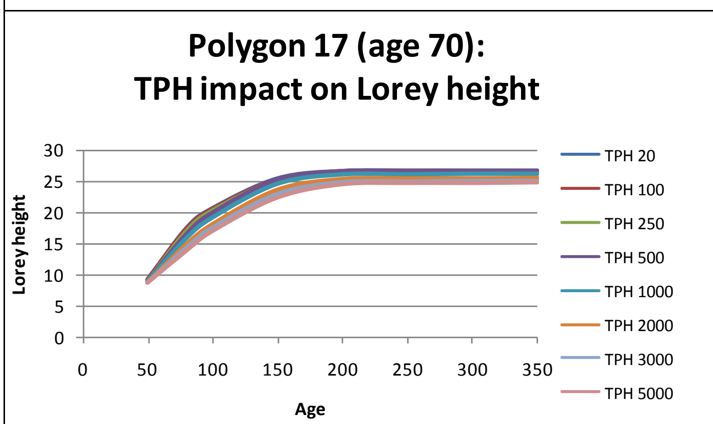

Polygon 5 (age 20):
TPH impact on Volume
Volume
350
300
250
200
150
100
50
0
0
50
100
150
200
250
300
350
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

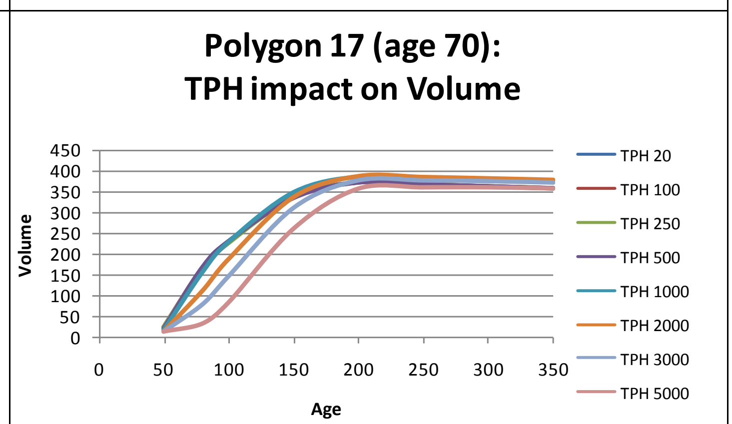
Appendix J_2: Effect of TPH change on Lorey height and volume over time

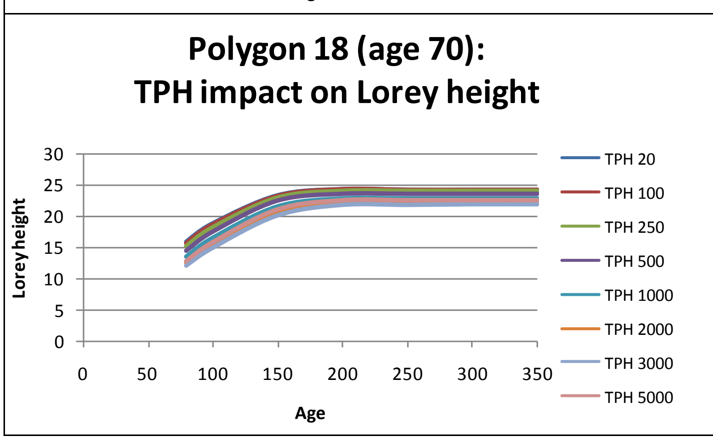
Polygons 30 to 80 years of age at reference year

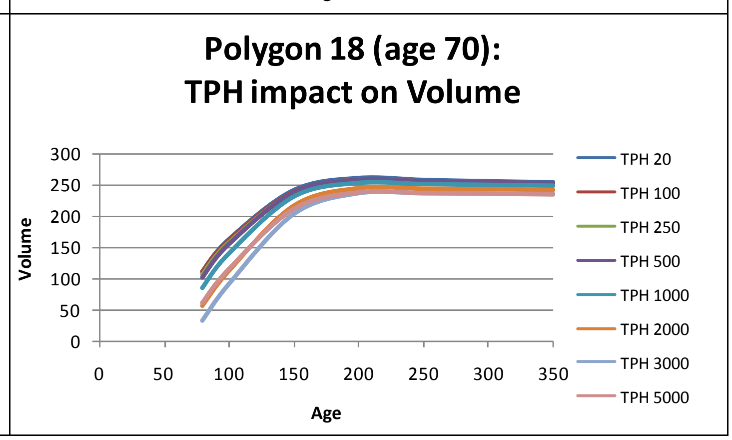


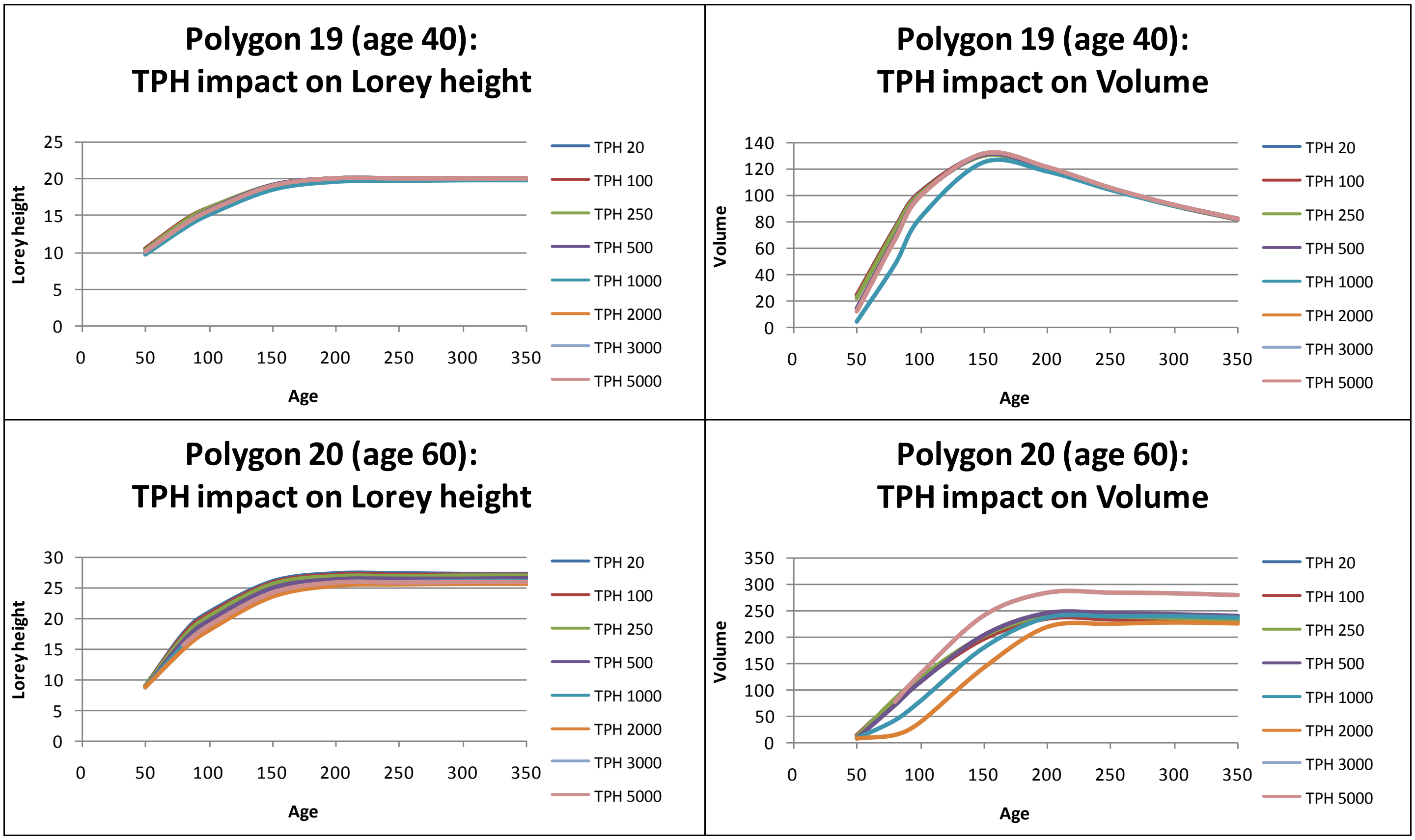






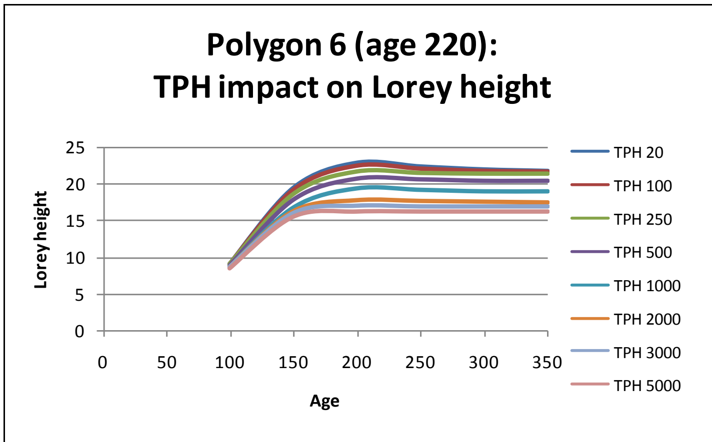


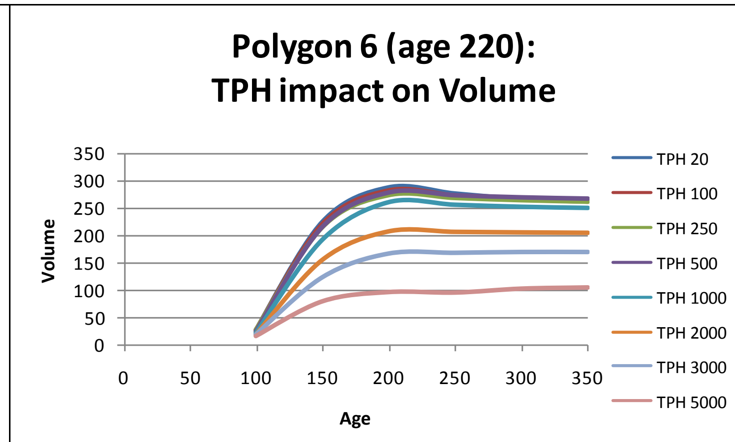


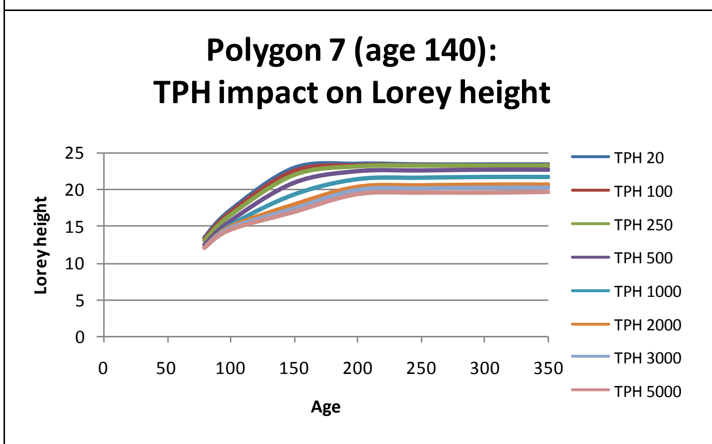

Polygon 19 (age 40):
TPH impact on Lorey height
Lorey height
Age
Polygon 19 (age 40):
TPH impact on Volume
Volume
Age
Polygon 20 (age 60):
TPH impact on Lorey height
Lorey height
Age
Polygon 20 (age 60):
TPH impact on Volume
Volume
Age
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

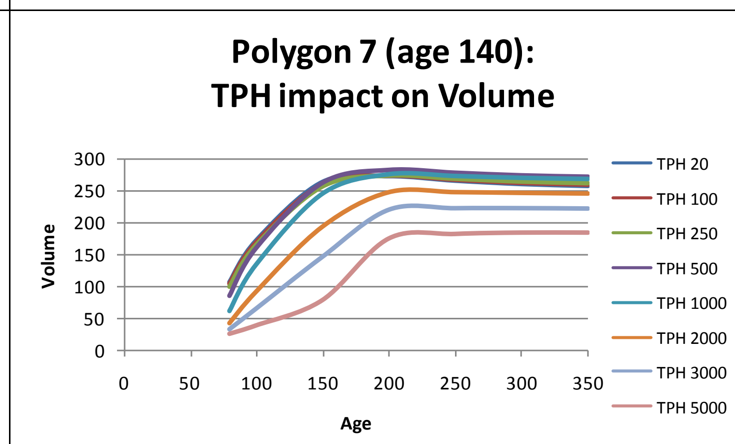
Appendix J_3: Effect of TPH change on Lorey height and volume over time

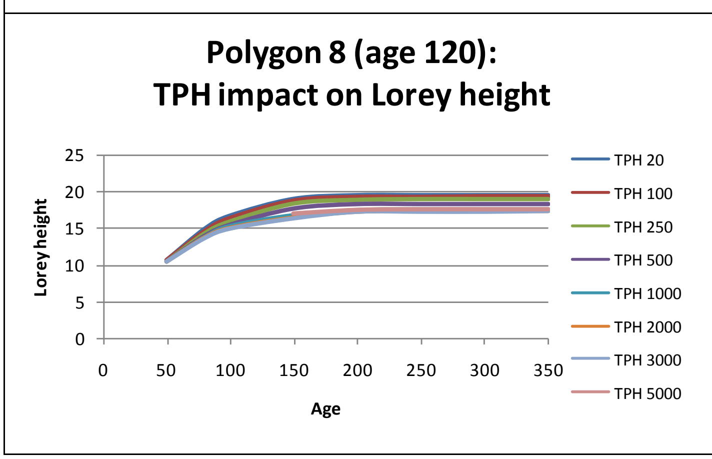
Polygons 81 to 249 years of age at reference year

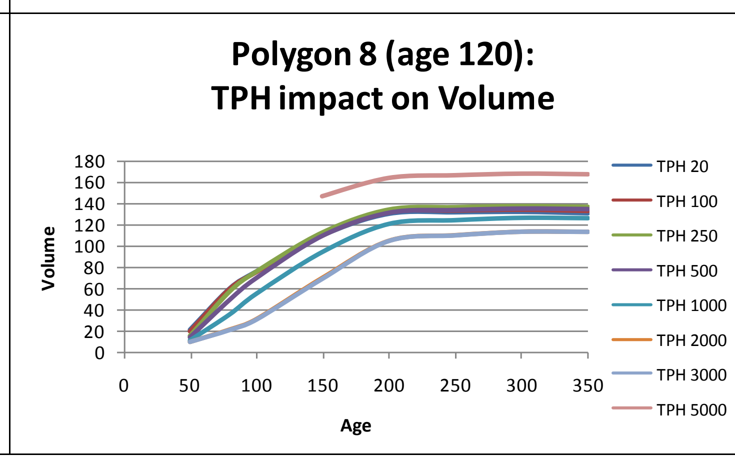


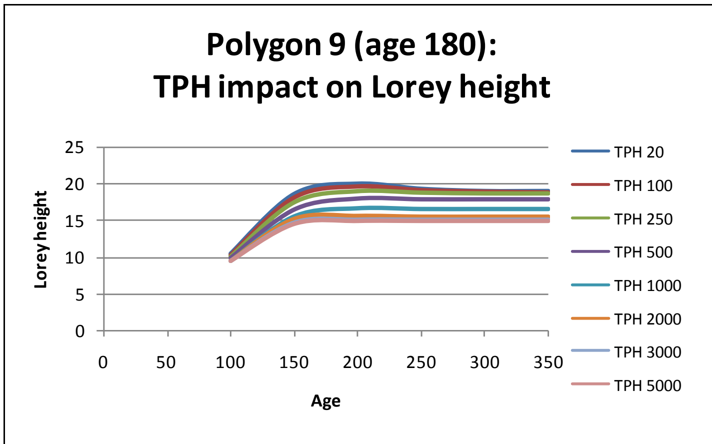


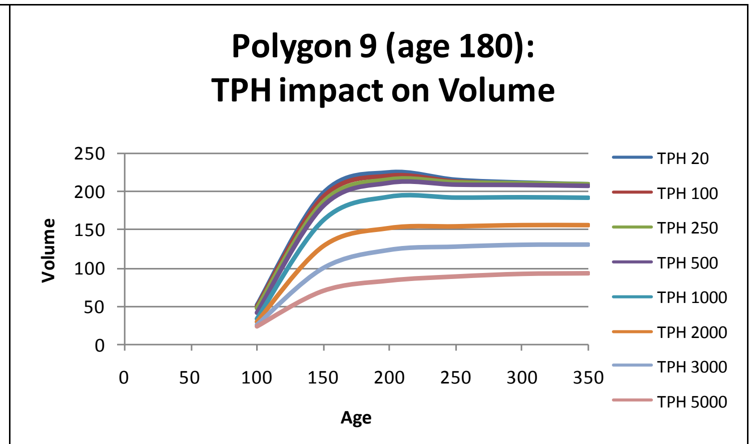


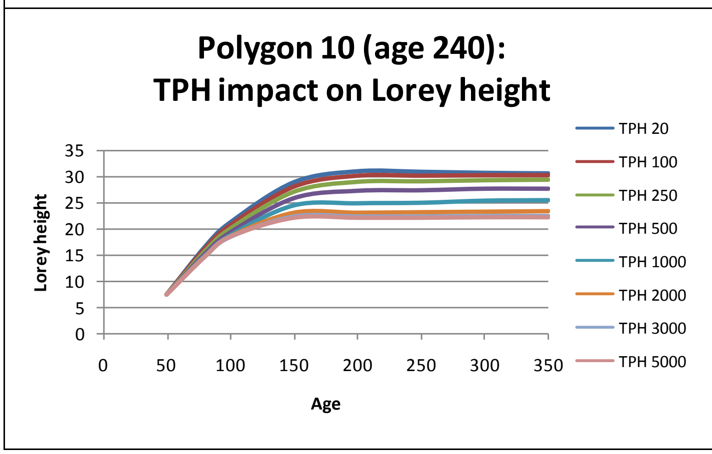


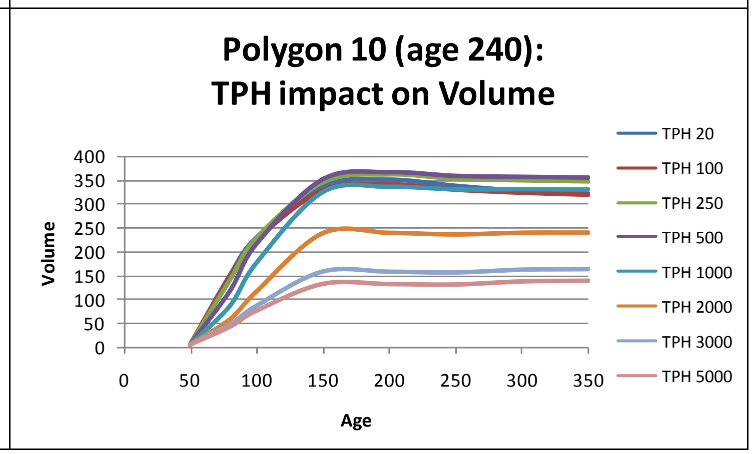





Polygon 9 (age 180):
TPH impact on Lorey height
Lorey height
Age
0
5
10
15
20
25
0
50
100
150
200
250
300
350
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

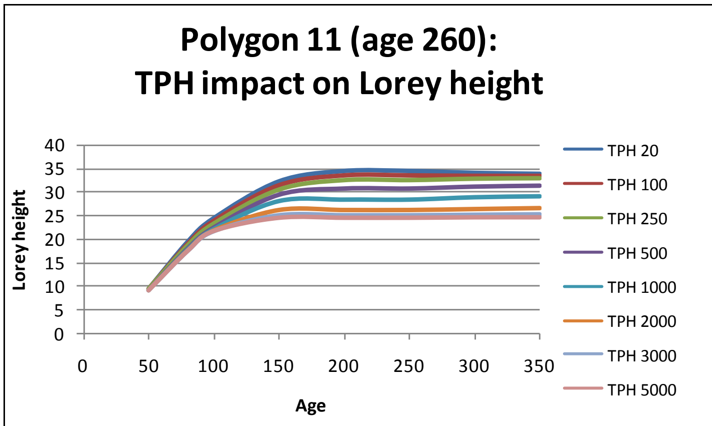

Polygon 9 (age 180):
TPH impact on Volume
Volume
Age
0
50
100
150
200
250
0
50
100
150
200
250
300
350
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

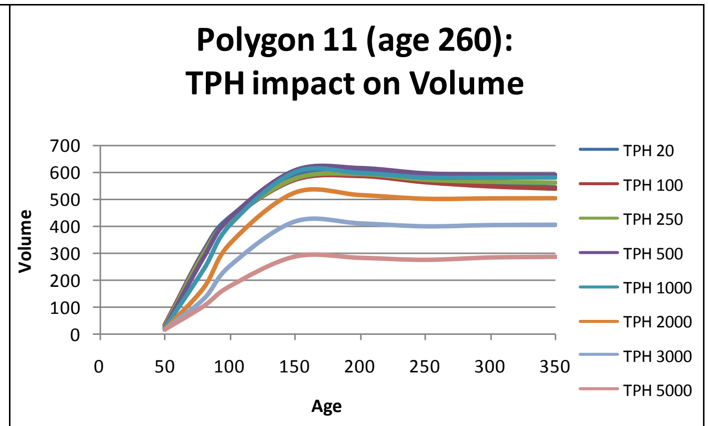

Polygon 10 (age 240):
TPH impact on Lorey height
Lorey height
Age
0
5
10
15
20
25
30
35
0
50
100
150
200
250
300
350
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

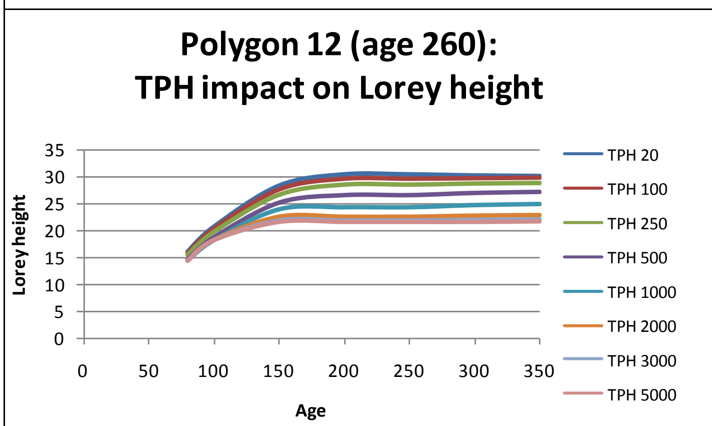

Polygon 10 (age 240):
TPH impact on Volume
Volume
Age
0
50
100
150
200
250
300
350
400
0
50
100
150
200
250
300
350
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

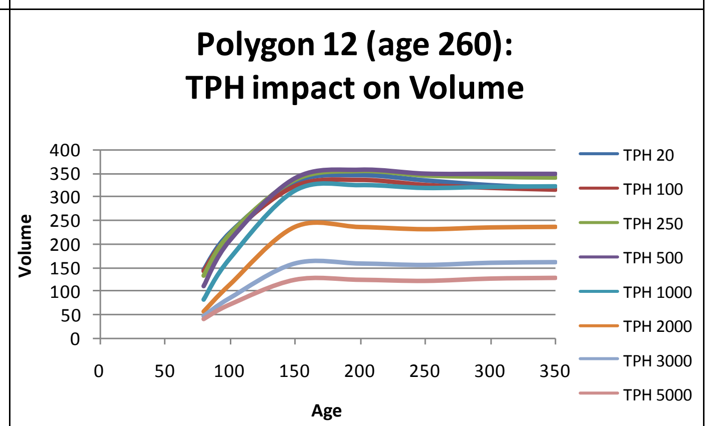
Appendix J_4: Effect of TPH change on Lorey height and volume over time

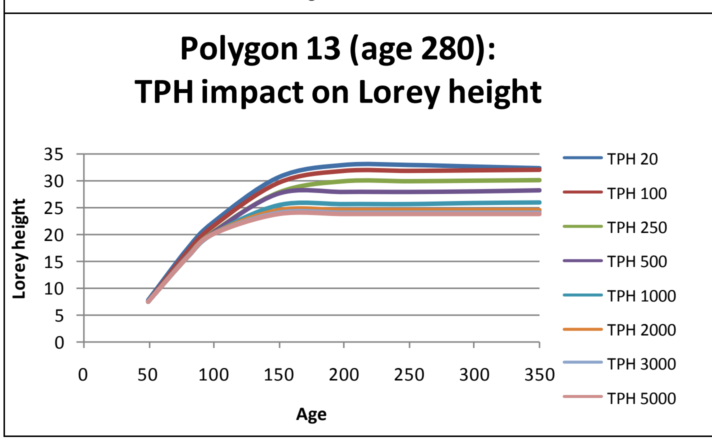
Polygons 250+ years of age at reference year

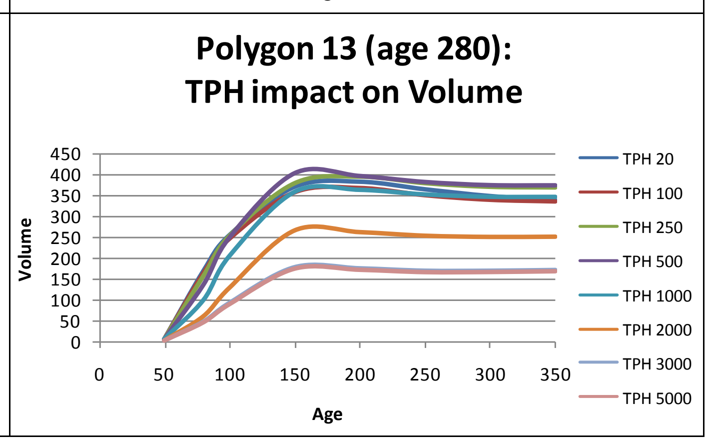


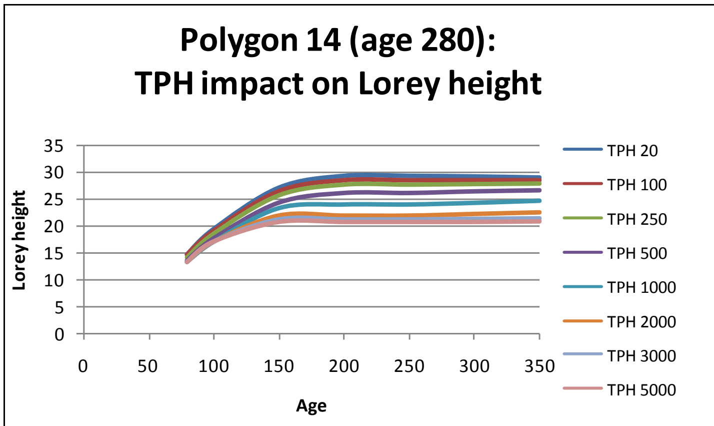


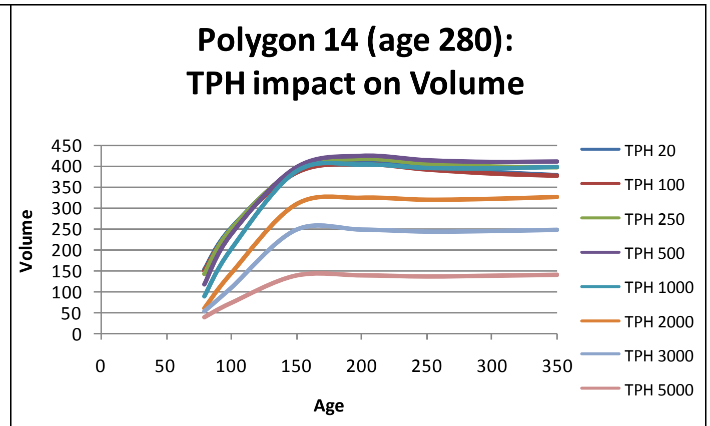


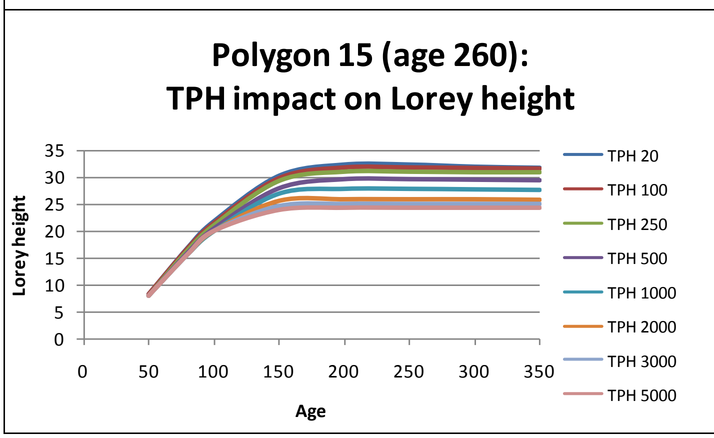


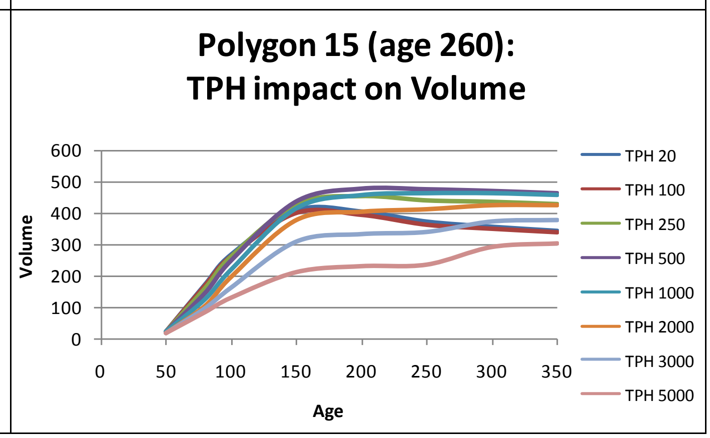





Polygon 14 (age 280):
TPH impact on Lorey height
Lorey height
Age
0 5 10 15 20 25 30 35
0 50 100 150 200 250 300 350
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

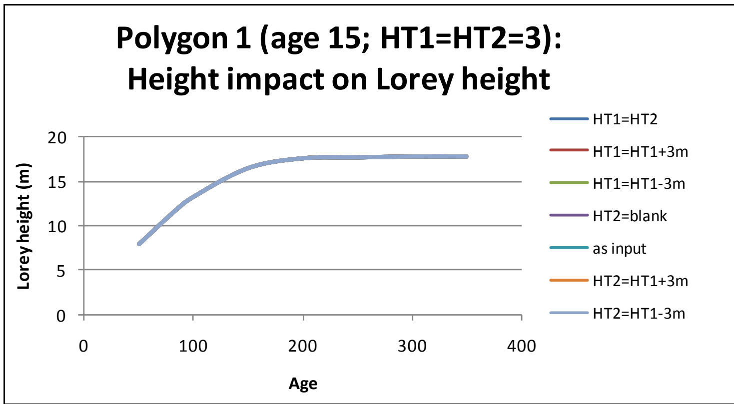

Polygon 14 (age 280):
TPH impact on Volume
Volume
Age
0 50 100 150 200 250 300 350 400 450
0 50 100 150 200 250 300 350
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

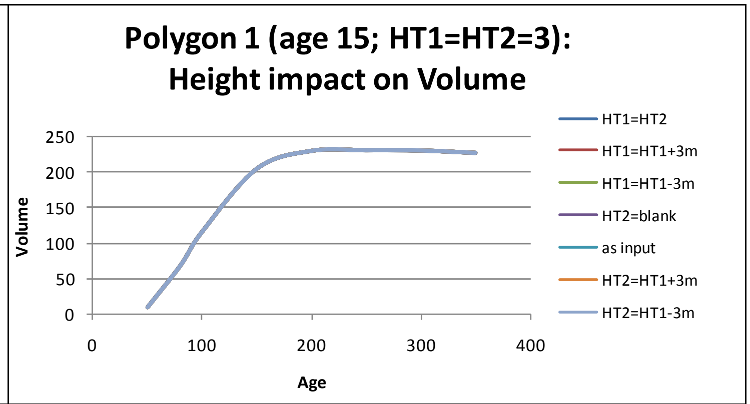

Polygon 15 (age 260):
TPH impact on Lorey height
Lorey height
Age
0 5 10 15 20 25 30 35
0 50 100 150 200 250 300 350
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

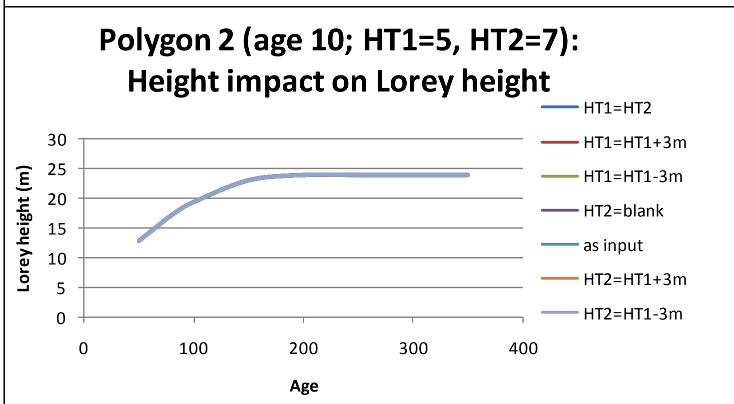

Polygon 15 (age 260):
TPH impact on Volume
Volume
Age
0 100 200 300 400 500 600
0 50 100 150 200 250 300 350
TPH 20
TPH 100
TPH 250
TPH 500
TPH 1000
TPH 2000
TPH 3000
TPH 5000

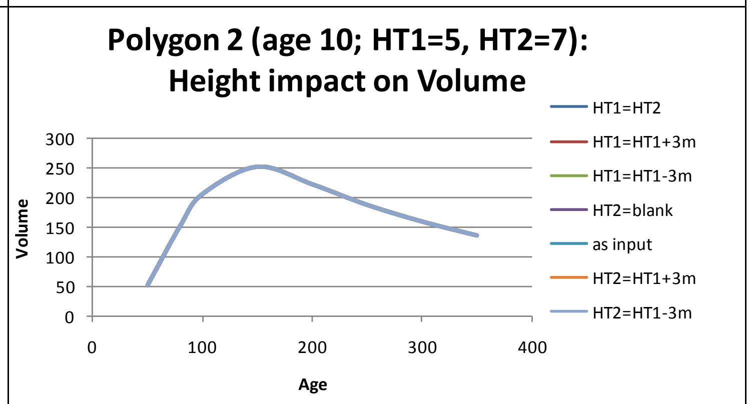
Appendix K_1: Effect of height change on Lorey height and volume over time

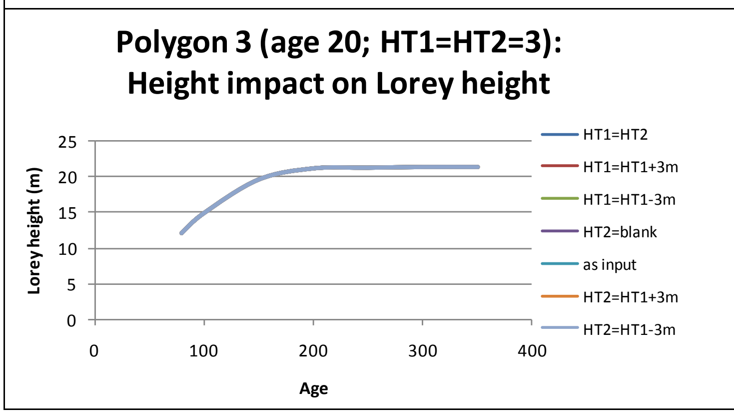
Polygons <30 years of age at reference year

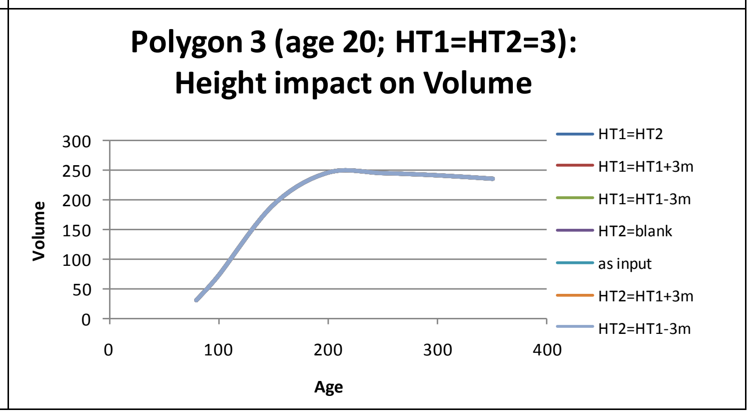


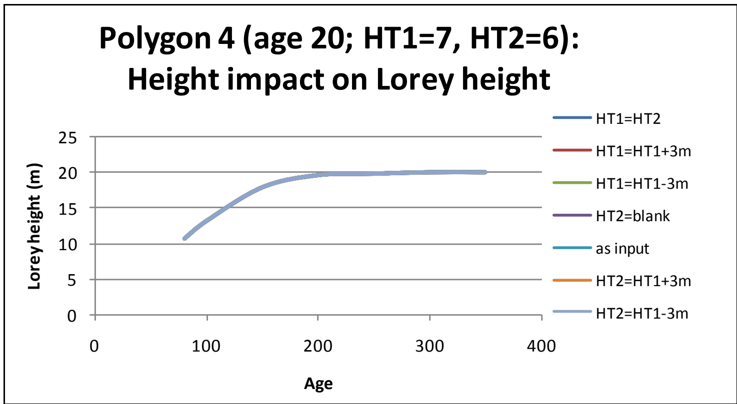




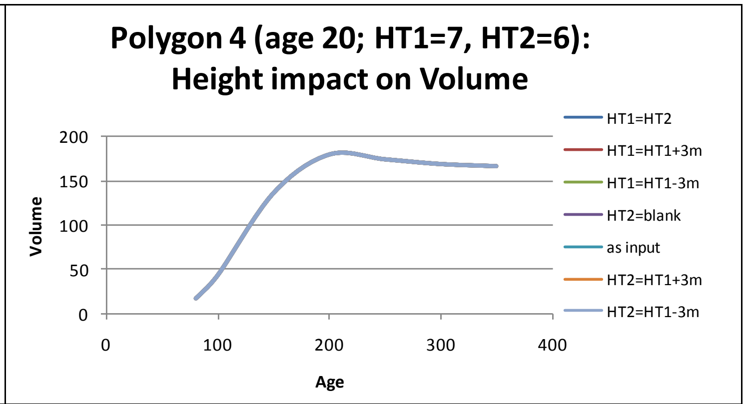




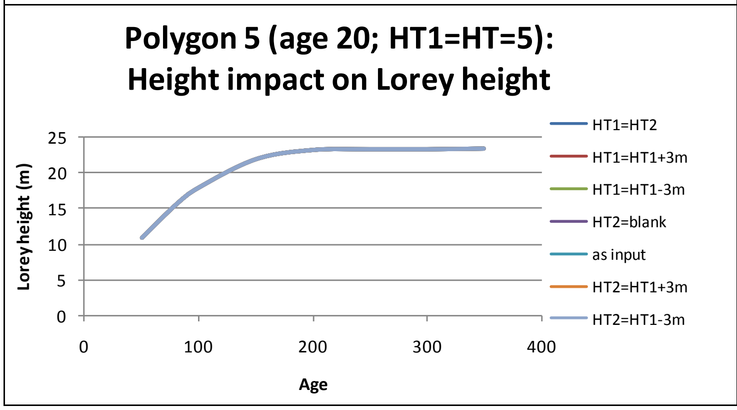




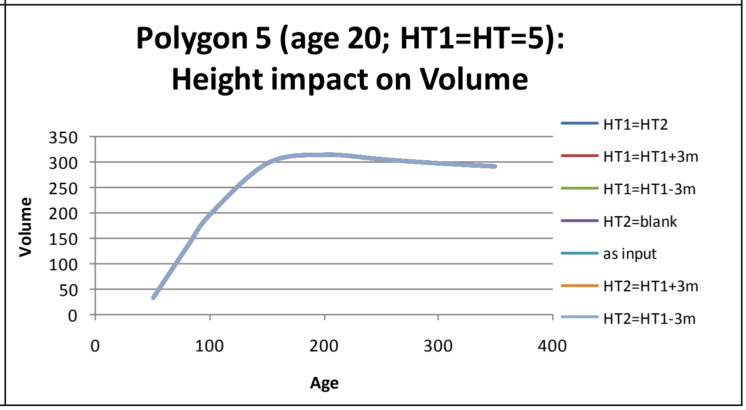
Polygon 4 (age 20; HT1=7, HT2=6):
Height impact on Lorey height
Lorey height (m)
Age
HT1=HT2
HT1=HT1+3m
HT1=HT1-3m
HT2=blank
as input
HT2=HT1+3m
HT2=HT1-3m



Polygon 4 (age 20; HT1=7, HT2=6):
Height impact on Volume
Volume
Age
HT1=HT2
HT1=HT1+3m
HT1=HT1-3m
HT2=blank
as input
HT2=HT1+3m
HT2=HT1-3m



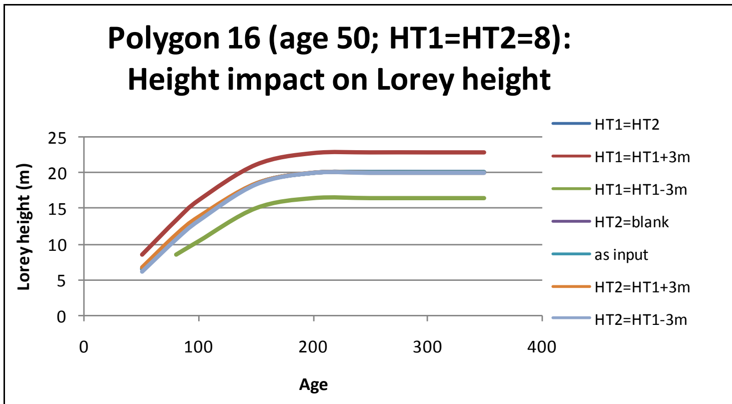
Polygon 5 (age 20; HT1=HT=5):
Height impact on Lorey height
Lorey height (m)
Age
HT1=HT2
HT1=HT1+3m
HT1=HT1-3m
HT2=blank
as input
HT2=HT1+3m
HT2=HT1-3m

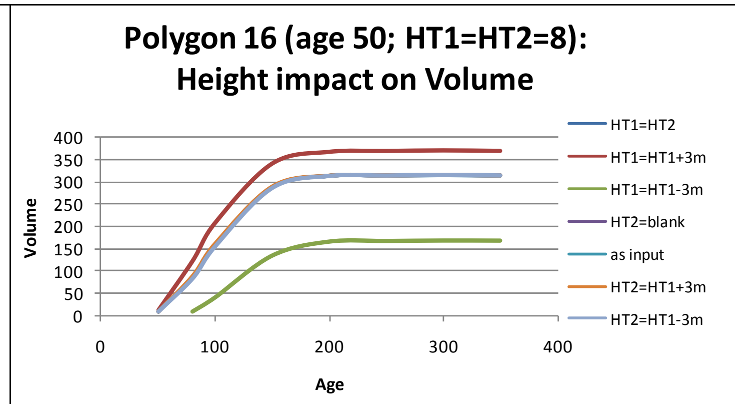


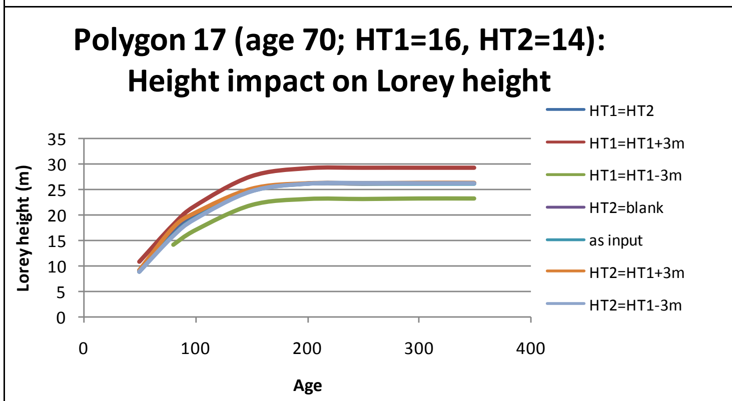
Polygon 5 (age 20; HT1=HT=5):
Height impact on Volume
Volume
Age
HT1=HT2
HT1=HT1+3m
HT1=HT1-3m
HT2=blank
as input
HT2=HT1+3m
HT2=HT1-3m

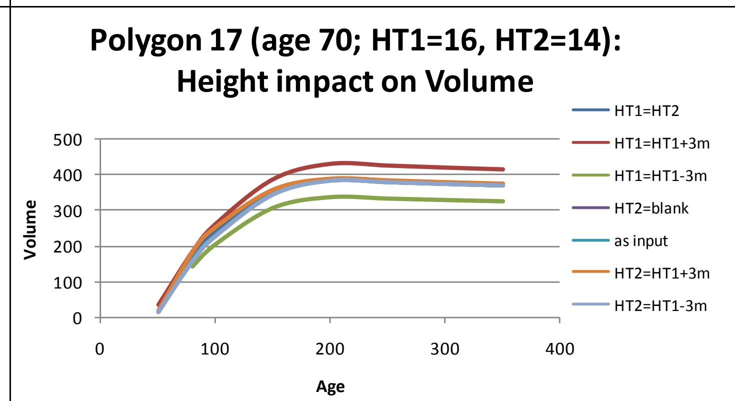
Appendix K_2: Effect of height change on volume over time

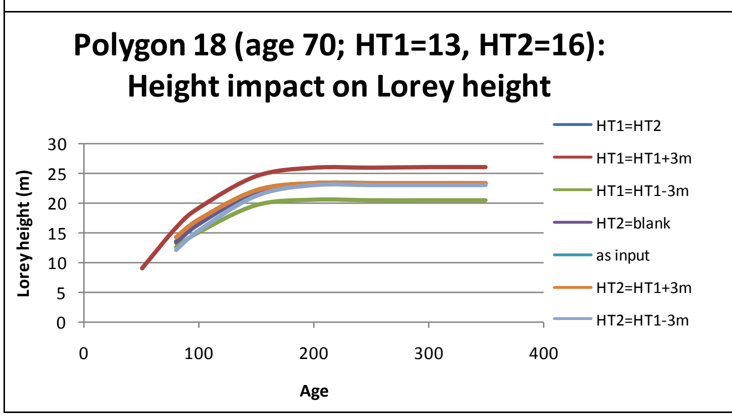
Polygons 30 to 80 years of age at reference year

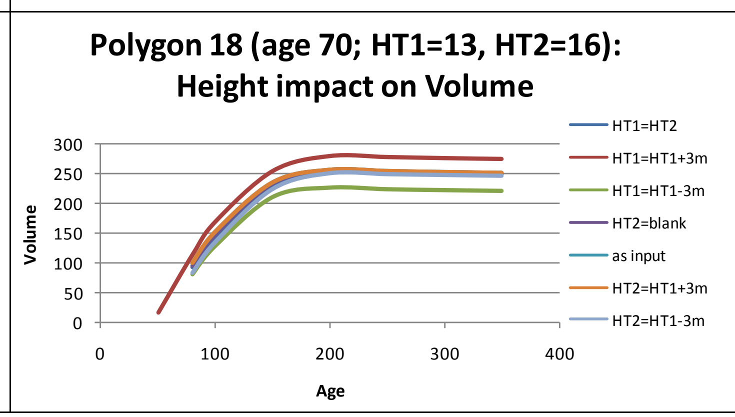


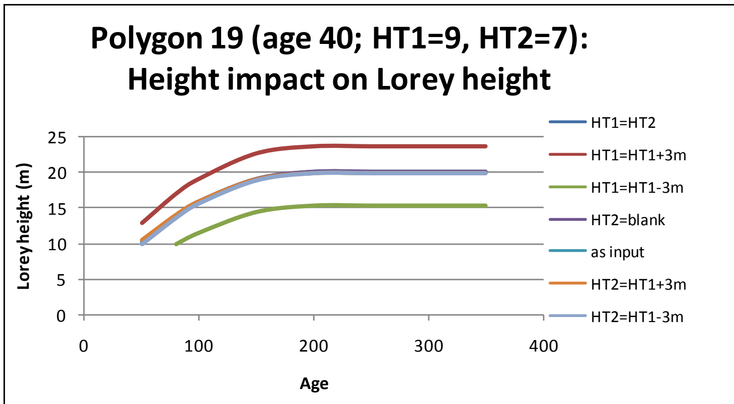


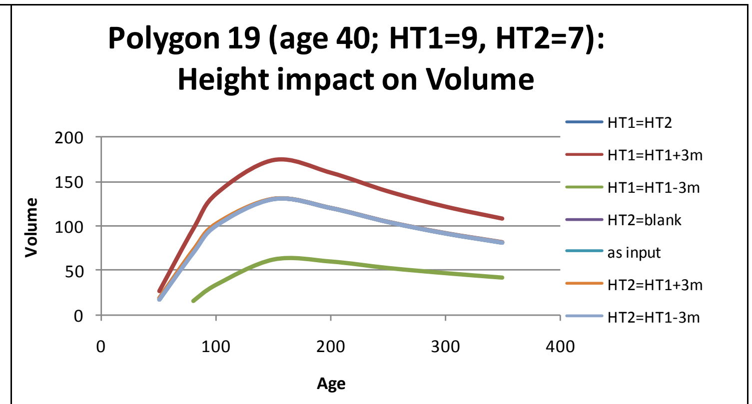


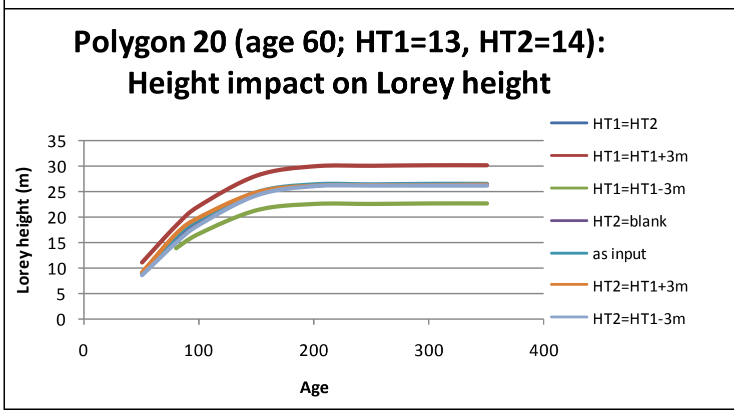


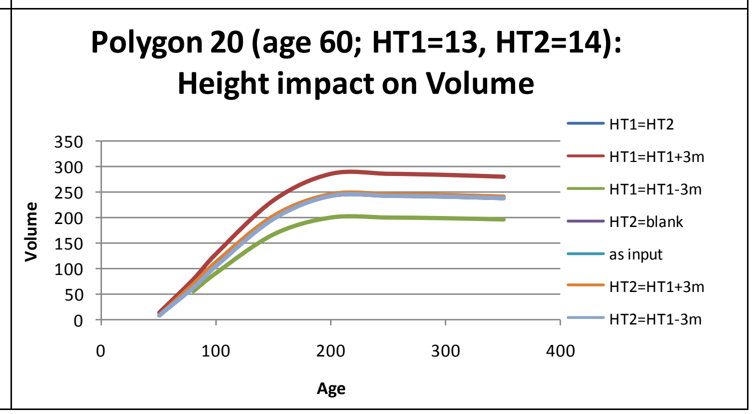





Polygon 19 (age 40; HT1=9, HT2=7):
Height impact on Lorey height
Lorey height (m)
Age
0
5
10
15
20
25
0
100
200
300
400
HT1=HT2
HT1=HT1+3m
HT1=HT1-3m
HT2=blank
as input
HT2=HT1+3m
HT2=HT1-3m


Polygon 19 (age 40; HT1=9, HT2=7):
Height impact on Volume
Volume
Age
0
50
100
150
200
0
100
200
300
400
HT1=HT2
HT1=HT1+3m
HT1=HT1-3m
HT2=blank
as input
HT2=HT1+3m
HT2=HT1-3m

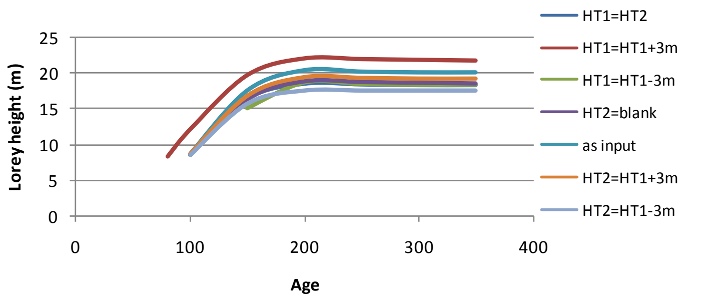

Polygon 20 (age 60; HT1=13, HT2=14):
Height impact on Lorey height
Lorey height (m)
Age
0
5
10
15
20
25
30
35
0
100
200
300
400
HT1=HT2
HT1=HT1+3m
HT1=HT1-3m
HT2=blank
as input
HT2=HT1+3m
HT2=HT1-3m


Polygon 20 (age 60; HT1=13, HT2=14):
Height impact on Volume
Volume
Age
0
50
100
150
200
250
300
350
0
100
200
300
400
HT1=HT2
HT1=HT1+3m
HT1=HT1-3m
HT2=blank
as input
HT2=HT1+3m
HT2=HT1-3m

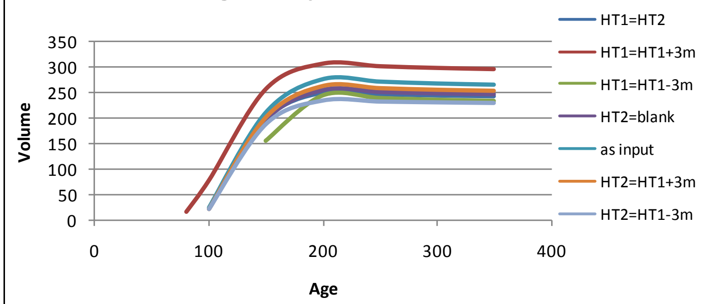
Appendix K_3: Effect of height change on volume over time

Polygons 81 to 249 years of age at reference year

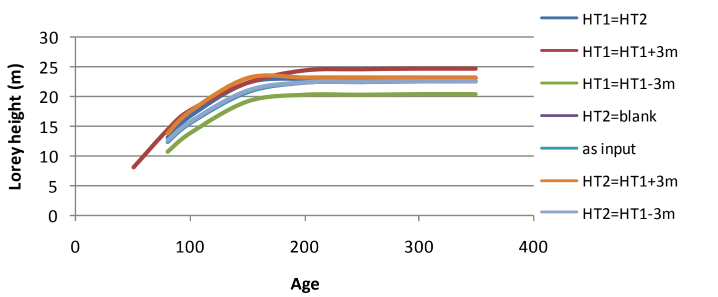
Polygon 6 (age 220; HT1=21, HT2=27): Height impact on Lorey height



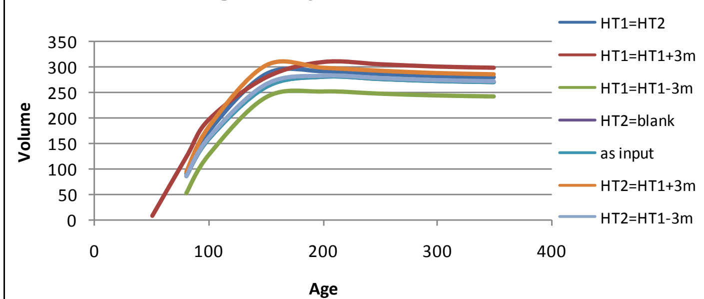
Polygon 6 (age 220; HT1=21, HT2=27): Height impact on Volume



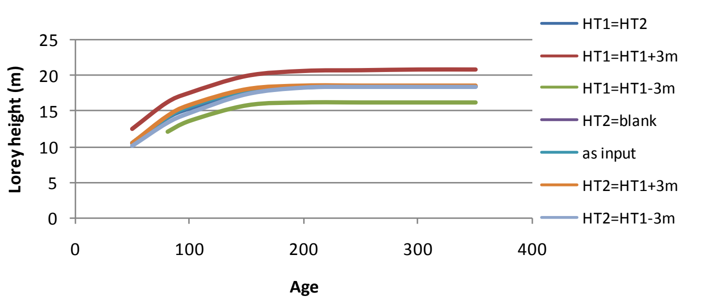
Polygon 7 (age 140; HT1=24, HT2=20): Height impact on Lorey height



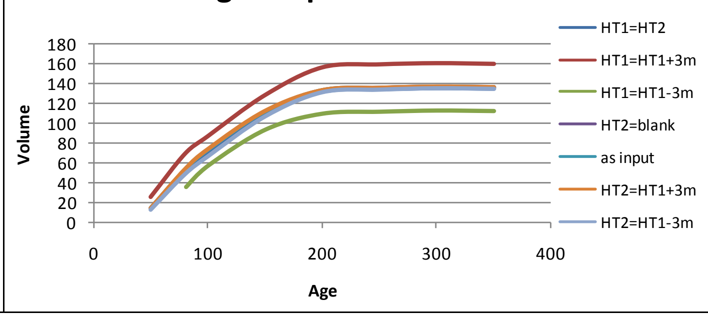
Polygon 7 (age 140; HT1=24, HT2=20): Height impact on Volume

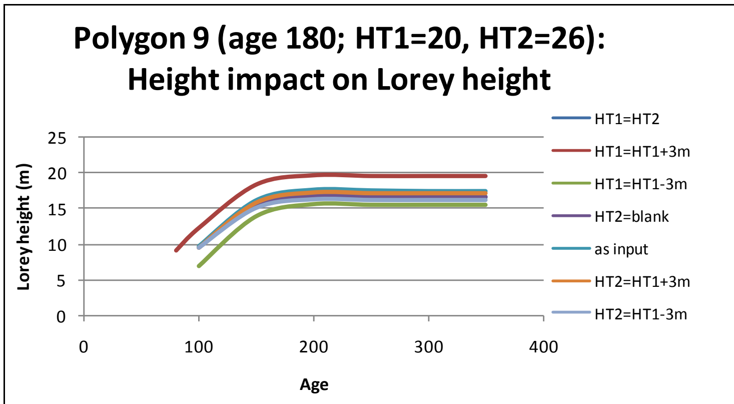


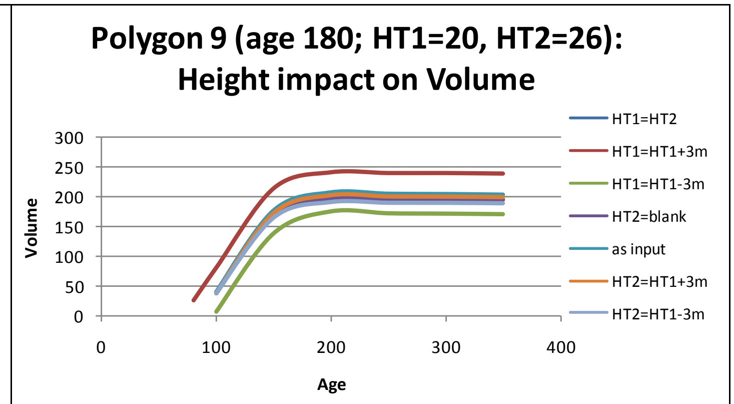
Polygon 8 (age 120; HT1=18; HT2=20): Height impact on Lorey height

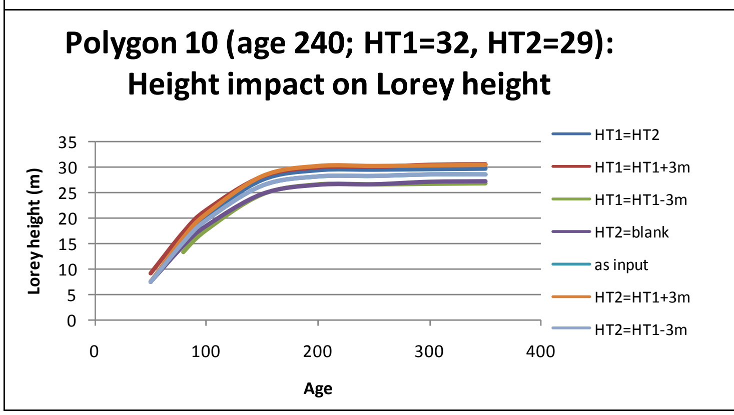


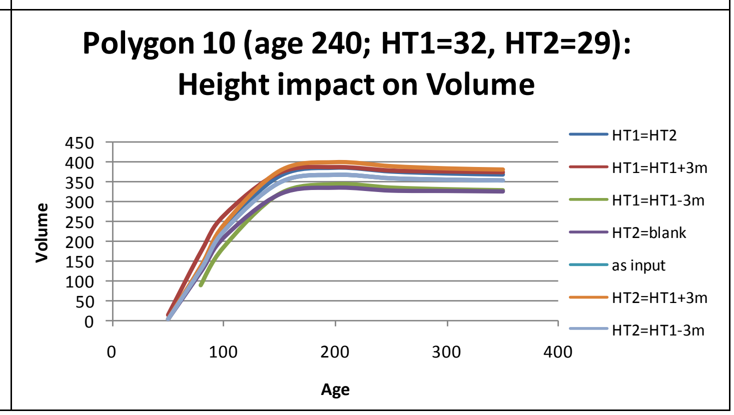
Polygon 8 (age 120; HT1=18; HT2=20): Height impact on Volume




Polygon 9 (age 180; HT1=20, HT2=26):
Height impact on Lorey height
Lorey height (m)
25
20
15
10
5
0
0
100
200
300
400
Age
HT1=HT2
HT1=HT1+3m
HT1=HT1-3m
HT2=blank
as input
HT2=HT1+3m
HT2=HT1-3m

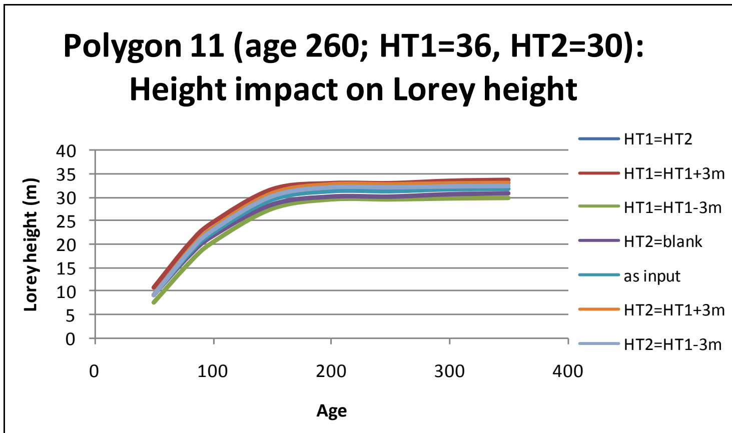

Polygon 9 (age 180; HT1=20, HT2=26):
Height impact on Volume
Volume
300
250
200
150
100
50
0
0
100
200
300
400
Age
HT1=HT2
HT1=HT1+3m
HT1=HT1-3m
HT2=blank
as input
HT2=HT1+3m
HT2=HT1-3m

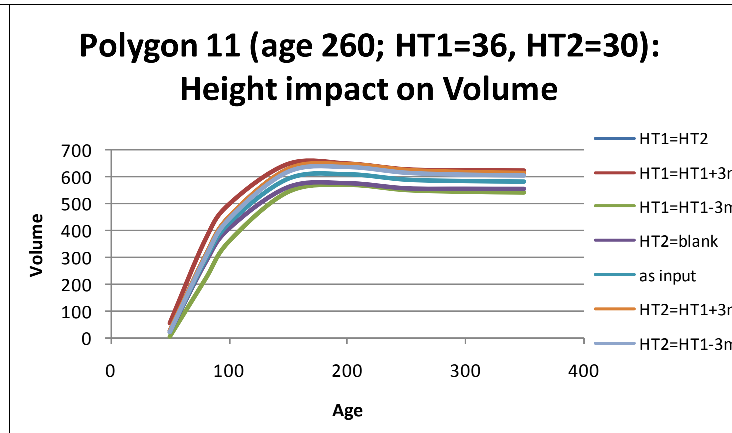

Polygon 10 (age 240; HT1=32, HT2=29):
Height impact on Lorey height
Lorey height (m)
35
30
25
20
15
10
5
0
0
100
200
300
400
Age
HT1=HT2
HT1=HT1+3m
HT1=HT1-3m
HT2=blank
as input
HT2=HT1+3m
HT2=HT1-3m

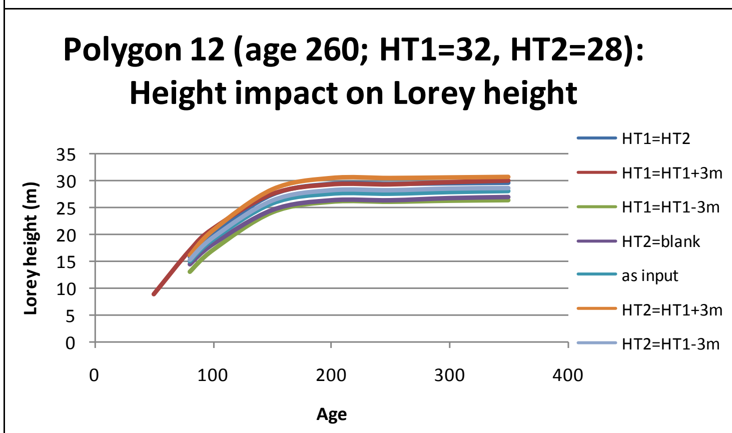

Polygon 10 (age 240; HT1=32, HT2=29):
Height impact on Volume
Volume
450
400
350
300
250
200
150
100
50
0
0
100
200
300
400
Age
HT1=HT2
HT1=HT1+3m
HT1=HT1-3m
HT2=blank
as input
HT2=HT1+3m
HT2=HT1-3m

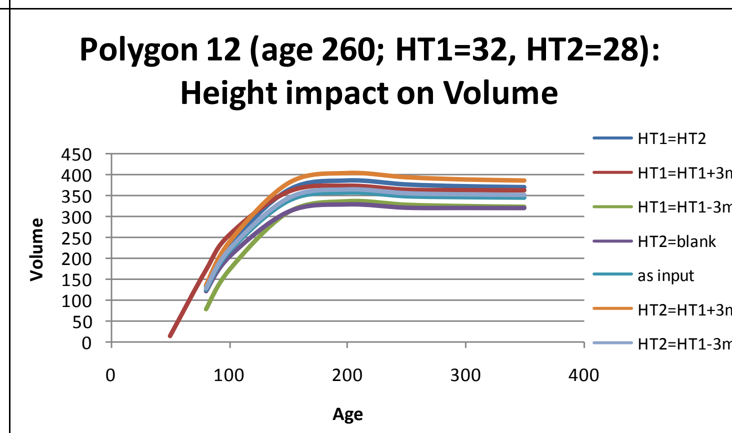
Appendix K_4: Effect of height change on volume over time

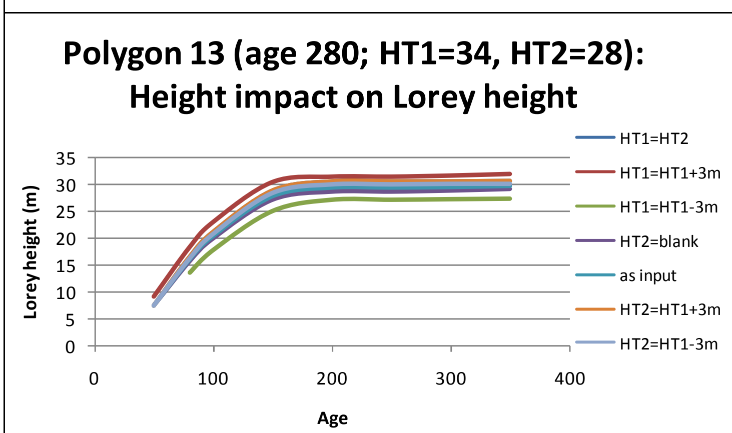
Polygons 250+ years of age at reference year

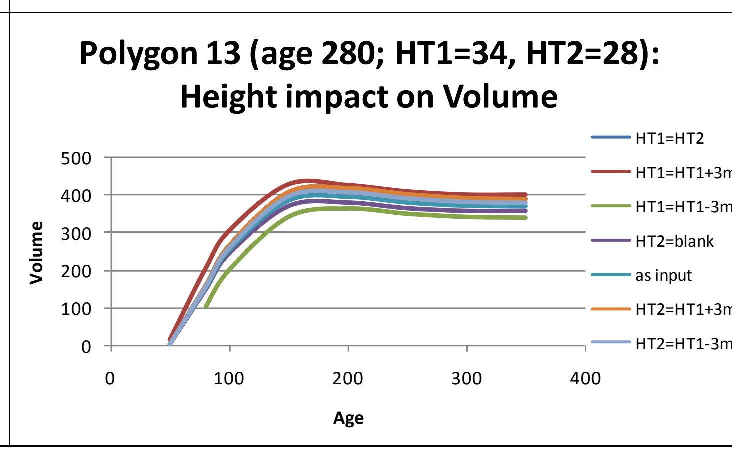


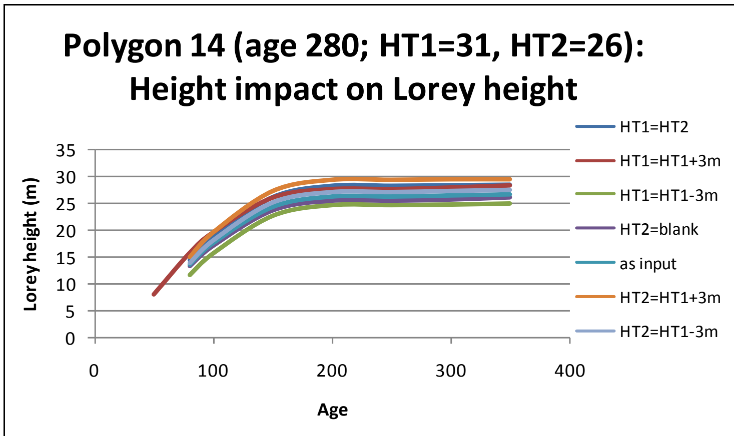


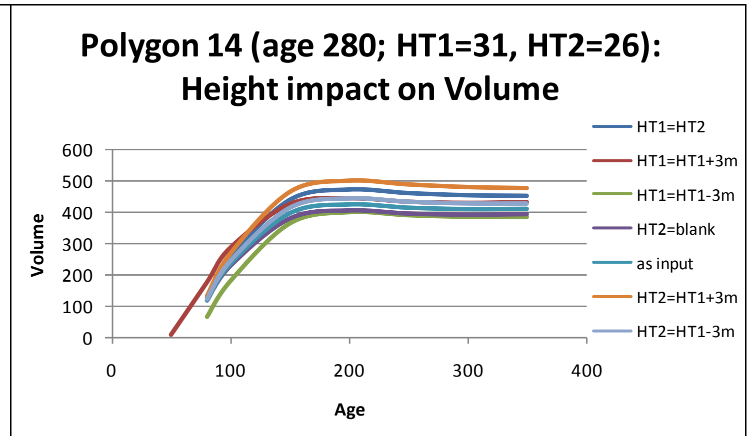


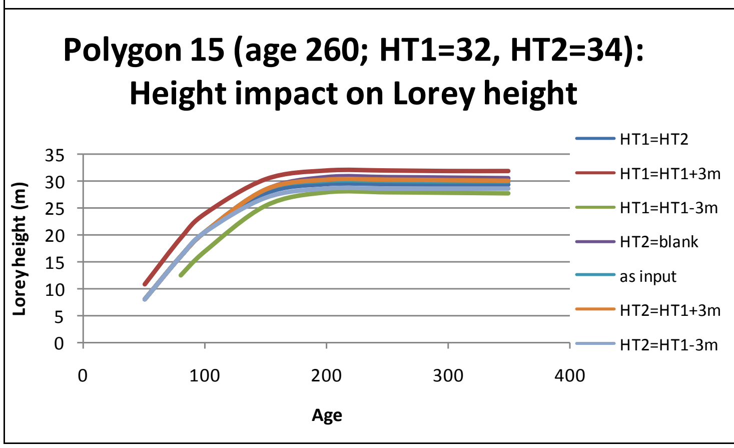


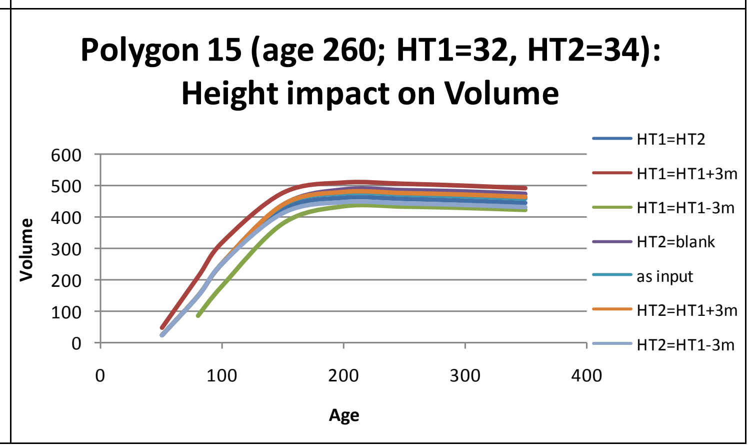





Polygon 14 (age 280; HT1=31, HT2=26):
Height impact on Lorey height
Lorey height (m)
Age
HT1=HT2
HT1=HT1+3m
HT1=HT1-3m
HT2=blank
as input
HT2=HT1+3m
HT2=HT1-3m


Polygon 14 (age 280; HT1=31, HT2=26):
Height impact on Volume
Volume
Age
HT1=HT2
HT1=HT1+3m
HT1=HT1-3m
HT2=blank
as input
HT2=HT1+3m
HT2=HT1-3m


Polygon 15 (age 260; HT1=32, HT2=34):
Height impact on Lorey height
Lorey height (m)
Age
HT1=HT2
HT1=HT1+3m
HT1=HT1-3m
HT2=blank
as input
HT2=HT1+3m
HT2=HT1-3m


Polygon 15 (age 260; HT1=32, HT2=34):
Height impact on Volume
Volume
Age
HT1=HT2
HT1=HT1+3m
HT1=HT1-3m
HT2=blank
as input
HT2=HT1+3m
HT2=HT1-3m