Millar Western Forest Products Ltd.

BAP SHE Yield Curve Documentation

2007-2016 Detailed Forest Management Plan

September 19, 2007

EXECUTIVE SUMMARY

The Biodiversity Assessment Project (BAP) is used by Millar Western Forest Products Ltd. to assess the effect of different forest management strategies on biodiversity using indicator models. These indicator models track several dimensions deemed important for biodiversity values through time and characterize the different ecosystem states on the forested, as well as the non-forested, the managed as well as the unmanaged landbase.

Some of these indicators were tracked directly in the Timber Supply Analysis model for roughly bounding forest management ecological feasibility space. This document describes the development of Special Habitat Element models used for ecologically bounding forecasts for the Millar Western 2007-2016 Detailed Forest Management Plan. Included are descriptions of the data used, the methods employed for creating relationships, and the resulting indicator models in graphical format.

Special Habitat Element models are representations of the development of biodiversity elements through time. Special Habitat Element models are stand level attributes that are used as building blocks for the more complex BAP Habitat Suitability Models. Examples are the percent of birch species in a stand, or the percent ground cover by fruit bearing shrubs.

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1. Introduction

1.1 Overview

The Biodiversity Assessment Project (BAP) is used by Millar Western to assess the effect of different forest management strategies on biodiversity using indicator models (Duinker and Doyon 2003, Messier et al. 2003). These indicator models track several dimensions deemed important for biodiversity values through time and characterize the different ecosystem states on the forested, as well as the non-forested, the managed as well as the unmanaged landbase. Through the previous planning process a number of indicators were identified as key to the planning process and are now required by the Government for demonstration of sustainability through the Value-Objective-Indicator-Target procedure (Alberta Sustainable Resources Development 2006). Some of these indicators were tracked directly in the forecasting model for roughly bounding forest management ecological feasibility space, while many other BAP indicators, like the vertebrate species Habitat Suitability Models (Higgelke et al. 2000), were analyzed on a draft PFMS using the BAP toolbox and results are documented in Doyon *et al.* (2006).

Landscape and ecosystem bioindicator models directly use the information from the forecasting projection tools and vegetation inventory coverage for their computation (Doyon and MacLeod 2000a). On the other hand, BAP Habitat Suitability Models describe local and contextual habitat quality based on the species' life requirement for realizing their crucial activities (foraging, reproduction, migration, hibernation, etc.) (Doyon and MacLeod 2000b). As such description of the habitat needs to be much finer. For instance, birds that are cavity nesters will depend on suitable standing trees (usually dead) for reproduction. Therefore, models that describe the availability of these habitat elements are required to predict change in these variables over time (Duinker *et al.* 2000). Special Habitat Element (SHE) models display such relationships between within-stand habitat elements and stand and site attributes (stand: composition, age, density, origin; site: ecosite, moisture index, productivity index).

Most of the SHE models are related to stand level attributes. Therefore, we used BAP strata, based on stand composition and age, for defining most SHE relationships (Table 1). A BAP stratum describes a forested habitat development sequence and can be directly linked with a stand description in the AVI, hence a forecasting species stratum. As the importance of many understory vegetation layers is dependent on the canopy closure, different individual curves were built to represent AB and CD density stands separately. Moreover, availability of certain SHE can be constrained by the stand origin (natural disturbance, clearcut or clearcut with variable retention) and subsequent stand tending activities, therefore separate curves were also created to represent different stand origin and management regimes (Table 2).

Table 1. Forested BAP strata.

Broad Cover Group	BAP Stratum	Description
D	AW	Aspen-leading deciduous stand
	PB	Poplar-leading deciduous stand
	BW	Birch-leading deciduous stand
DC	AW_PL	Aspen or birch-leading pine mixedwood stand
	AW_SWSB	Aspen or birch-leading spruce mixedwood stand
	PB_CON	Poplar-leading mixedwood stand
CD	PL_DEC	Pine-leading mixedwood stand
	SWSB_DEC	Spruce-leading mixedwood stand
C	PL	Pine-leading coniferous stand
	SB Lowland[1]	Black-spruce leading coniferous stand, lowland sites
	SB Upland[2]	Black-spruce leading coniferous stand, upland sites
	SW	White spruce-leading coniferous stand
	LT	Larch-leading coniferous stand

[1]Black spruce stands with a TPR of U were deemed spruce lowland sites.

[2]Black spruce stands with a TPR of F, M or G were deemed spruce upland sites.

Table 2. Stand origin and management regimes.

Stand Origin	Management Regime	Name Code	Curve Code	Description
Fire Origin	Natural Stand	NATURAL ORIGIN	NatOrig-VR30[1]	Fire origin stands with no harvesting
	Commercial Thin	THINNING	NatOrig+Thin	Fire origin stands with commercial thinning
Managed	Clearcut	MANAGE	Manage	Managed stands (clearcut)
	Clearcut/30%VR	VR-30	NatOrig-VR30[1]	Managed stands with 30% variable retention
	Clearcut/15%VR	VR-15	VR15	Managed stands with 15% variable retention
	Crop Plan	CROP PLAN	CropPlan	Managed stands with stand density management
	Commercial Thin	THINNING	Manage+Thin	Managed stands with commercial thinning (SB Uplands)

[1] The same curve was used to represent natural stands and managed stands with 30% variable retention.

[P1]

The reader can find the list of the SHE models that have been used for bounding forest management ecological feasibility space, their codes and descriptions in Table 3. These SHE models were specifically developed in order to meet the VOIT requirements and are more general than the SHEs that were used for the Habitat Suitability Models (Table 4).

Table 3. Special Habitat Element models used for ecologically bounding forecasts

Code	Special Habitat Element Description
DENS_DC20+	Density of dead coniferous trees (snags) 20+ cm DBH
DENS_DC40	Density of dead coniferous trees (snags) 40+ cm DBH
DENS_DD20+	Density of dead deciduous trees (snags) 20+ cm DBH
DENS_DD40	Density of dead deciduous trees (snags) 40+ cm DBH
DENS_LC0	Density of SAPLINGS (< 7.1 CM) live coniferous trees
DENS_LD0	Density of all SAPLINGS (< 7.1 CM) live deciduous trees
DWD_Vol	Volume of down woody debris
MEANDBH	Average DBH
Oldgrowthness	Proportion of "oldgrowthness"
Basal Area	Total basal area
FMFS	Free-to-manoever flying space (CLEAR, ENTANGLED, POROUS/OBSTRUCTED)
Herb	Percent ground cover of herbs (ALL: LARGE-LEAVED AND GRAMINOIDS)
Shrub	Percent ground cover of shrubs (TALL SHRUB)

[P2]

Table 4. Special Habitat Element models used by the Habitat Suitability Models for the biodiversity assessment of the first draft of the Preferred Forest Management Strategy.

Type	Code	Description
Stand composition	Aw %	Basal area % of *Populus tremuloides* trees (DBH ≥ 7.1 cm) in the stand
Stand composition	Pb %	Basal area % of *Populus balsamifera* trees (DBH ≥ 7.1 cm) in the stand
Stand composition	Bw %	Basal area % of *Betula papyrifera* trees (DBH ≥ 7.1 cm) in the stand
Stand composition	Pl %	Basal area % of *Pinus* spp. trees (DBH ≥ 7.1 cm) in the stand
Stand composition	Sw %	Basal area % of *Picea glauca* trees (DBH ≥ 7.1 cm) in the stand
Stand composition	Sb %	Basal area % of *Picea mariana* trees (DBH ≥ 7.1 cm) in the stand
Stand composition	Fb %	Basal area % of *Abies balsamea* trees (DBH ≥ 7.1 cm) in the stand
Stand composition	Lt %	Basal area % of *Larix* spp. trees (DBH ≥ 7.1 cm) in the stand
Stand composition	Coniferous %	Basal area % of conifer trees (DBH ≥ 7.1 cm) in the stand
Stand composition	Deciduous %	Basal area % of deciduous trees (DBH ≥ 7.1 cm) in the stand
Stand structure	DENS (Live trees, Aw, Pb, DBH ≥ 25 cm & ht ≥ 7m)	Density (ha-1) of live Aw & Pb with DBH ≥ 25 cm and height ≥ 7 m
Stand structure	DENS (Live trees, Aw, Pb, Sw DBH ≥ 40 cm)	Density (ha-1) of live Aw, Pb and Sw with DBH ≥ 40 cm
Stand structure	DENS (Live trees, DBH ≥ 25 cm)	Density (ha-1) of live trees with DBH ≥ 25 cm
Stand structure	DENS (Snags conifers DBH ≥ 20 cm)	Density (ha-1) of dead coniferous trees with DBH ≥ 20 cm
Stand structure	DENS (Snags, DBH ≥ 20 cm)	Density (ha-1) of dead trees with DBH ≥ 20 cm
Stand structure	DENS (Snags, diseased or damaged trees, DBH ≥ 25 cm)	Density (ha-1) of dead, diseased & damaged trees with DBH ≥ 25 cm
Stand structure	DWD cover %	% of the forest floor cover by downed woody debris (diam ≥ 10 cm)
Stand structure	DWD volume	Downed woody debris (diam ≥ 10 cm) volume (m^3 ha^{-1})
Stand structure	FMFS	Free-to-Manoeuver-Flying-space index (3 classes)
Stand structure	H2LC	Height to live crown (m)
Stand structure	Age	Stand age (years)
Stand structure	Height	Stand height (m)
Understory vegetation	Arboreal lichen index	Arboreal lichen index (Dimensionless)
Understory vegetation	Fruit-bearing shrub cover %	% of the forest floor cover by fruit-bearing shrub
Understory vegetation	Ground lichen %	% of the forest floor cover by ground lichen
Understory vegetation	Herbaceous %	% of the forest floor cover by herbs (all types)
Understory vegetation	Low shrub %	% of the forest floor cover by shrub < 1 m
Understory vegetation	Shrub cover ≥ 0.20 m %	% of the forest floor cover by shrub ≥ 0.2 m
Understory vegetation	Shrub cover ≥ 1 m %	% of the forest floor cover by shrub ≥ 1 m
Understory vegetation	Tall Shrub cover ≥ 2 m %	% of the forest floor cover by shrub ≥ 2 m
Understory vegetation	Willow %	% of the forest floor cover by *Salix* spp. shrubs
Understory vegetation	Willow & rose %	% of the forest floor cover by *Salix* spp. and rose shrubs

In the previous Detailed Forest Management Plan (DFMP), SHE relationships were derived from data gathered in the Temporary Sample Plots and the Permanent Sample Plots (Doyon and McLeod 2000b). However, in MWFP's first sampling program, some forest conditions were under sampled. Therefore, several relationships were not supported by the data but were rather based on expert knowledge (see Doyon and MacLeod 2000b for a better description of the methodology used then). As MWFP improved its sampling program, new information has been collected, allowing a clarification of the relationships used in the SHE models. This document describes the development of SHE curves for the 2007-2016 DFMP.

1.2 General Methodology

Special Habitat Elements were developed based on empirical relationships using the inventory plots (Doyon and MacLeod 2003b). All plots from 2 different inventory protocols sampled from 1996 to 2005 were used, generating a total of 1892 plots (Table 5). However, because of different information quality criteria (missing data, spatial integrity, stands with no trees, plots within non-forested stands, etc.), we rejected 207 plots for the analysis (1685 in total retained).

Table 5. Number of plots used by protocol and year of sampling.

Inventory Protocol	Year	Number of Plots
PSP	1996	25
PSP	1997	41
PSP	1998	54
PSP	1999	10
PSP	2000	31
PSP	2001	43
PSP	2003	105
PSP	2004	40
TSP	1997	465
TSP	1998	120
TSP	2000	359
TSP	2004	563
TSP	2005	36
Total		1892
Plots rejected		207
Total Retained		1685

Each plot is spatially related to a stand in the forest inventory. Stands have been assigned to a DFMP Yield Stratum and a BAP Stratum according to species composition as detected by the photo-interpreted forest inventory (AVI 2.1). BAP strata are aligned with the habitat classification in order to have a BAP stratum for each BAP specific habitat classification group (see Doyon 2000). Plot/stand spatial relationships relate the tree composition observed in the plots with the stand's BAP stratum. Some BAP strata were less well represented than others because of their rather marginal importance in the landscape (Table 6), particularly Pl_Pb, Sb_Aw and Sw_Pb. Because of that, we decided not to have different BAP strata for each Forest Management Unit (FMU) (W13 and W11) nor for each natural subregion (UF, LF, BM and CM).

Table 6. Number of plots by BAP stratum and by stand age class. Cells with less than of equal to 2 plots are in dark grey. Cells with less than of equal to 5 plots are in light grey.

Stand age class (years)	BAP composition strata (BCS)															
	Aw	Aw_Pl	Aw_SwSb	Bw	Lt	Pb_Con	Pl	Pl_Aw	Pl_Pb	Pb	Sb	Sb_Aw	Sw	Sw_Aw	Sw_Pb	Total
1	10	2	6	0	2	1	48	3	0	0	23	2	21	2	1	121
11	0	2	6	0	0	0	9	4	0	1	0	0	2	2	0	26
21	10	0	0	0	0	0	0	0	0	0	3	0	0	2	0	15
31	38	0	2	0	1	1	5	3	0	2	1	0	0	0	0	53
41	19	0	3	1	1	0	12	0	0	0	0	0	10	3	0	49
51	30	9	11	12	3	0	57	27	0	2	6	0	12	3	2	174
61	52	22	19	3	2	5	86	18	2	3	16	3	11	4	0	246
71	9	0	3	0	0	3	40	4	1	1	30	0	28	3	0	122
81	24	0	6	0	5	0	3	0	0	0	7	0	8	5	0	58
91	22	9	7	0	0	0	14	1	0	0	5	0	6	11	0	75
101	43	18	13	0	1	0	52	16	0	1	6	0	19	11	0	180
111	37	11	19	0	5	0	18	7	0	4	9	0	31	13	0	154
121	22	24	19	0	4	3	35	11	0	3	28	0	31	16	2	198
131	8	1	20	0	0	0	17	0	0	0	17	0	40	26	0	129
141	0	3	0	0	0	1	8	0	0	0	7	0	4	0	0	23
151	0	0	0	0	0	0	17	11	0	0	6	0	2	0	0	36
161	0	0	0	0	1	0	5	6	0	0	3	0	1	0	0	16
171	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	4
181	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	4
201	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
Total	324	101	134	16	27	14	426	111	3	17	174	6	226	101	5	1685

* Stand age in 10-years classes (1=0 to 5 years, 11=6 to 15 years, and so on).

Given the number of plots by age decade and BAP stratum, very few BAP strata had a complete and well-represented age gradient (Aw, Aw_Pl, Aw_SwSb, Pl, Pl_Aw, Sb, Sw, Sw_Aw, Table 6). Because of that, some BAP strata have been grouped together for the analysis (Table 7). We also deemed it important to separate upland black spruce stands from lowland black spruce stands as their habitat structure and stand dynamics are quite different. Black spruce stands with an unproductive AVI timber productivity rating ("U") were considered lowland black spruce stands.

Table 7. Final BAP strata.

Broad Cover Group	Original BAP Stratum	Final BAP Stratum
D	AW	AW
	PB	PB
	BW	BW
DC	AW_PL	AW_PL
	AW_SB, AW_SW	AW_SWSB
	PB_CON	PB_CON
CD	PL_DEC	PL_DEC
	SB_AW, SW_AW, SW_PB	SWSB_DEC
C	PL	PL
	SB Lowland[1]	SB Lowland
	SB Upland[2]	SB Upland
	SW	SW
	LT	LT

[1]Black spruce stands with a TPR of U were deemed spruce lowland sites.

[2]Black spruce stands with a TPR of F, M or G were deemed spruce upland sites.

As the plots used for the analysis come from stands originating from a natural disturbance (fire in almost all cases), the empirical relationships derived from the dataset describe the behaviour for NATURAL ORIGIN stands without any tending treatment during its development. In order to represent the behaviour of each SHE under other origin or management regimes (VARIABLE RETENTION-30% and -15%, MANAGE, MANAGE WITH THINNING, CROP PLAN, NATURAL ORIGIN WITH THINNING), the curves generated from the data fitted models have then been modified based on silvicultural strategy objectives and expectations. The following presents some general rules that have been used for generating those curves.

MANAGE: Vegetation Management Strategies (VMS) are applied under the MANAGE and VR-15 regimes to control competition from herb at the seedling stage and from shrub and deciduous saplings at the sapling stage. Consequently, herb, shrub and deciduous sapling cover values are adjusted based on identified vegetation community transitions (MWFP 2005). As MANAGE yield curves are greater than NATURAL ORIGIN ones, basal area will be higher, mean DBH will reach a higher value, stands will be fully stocked, etc.

NATURAL ORIGIN WITH THINNING AND MANAGE WITH THINNING: THINNING, when applied, reduces the density by 30% but maintains the DBH distribution just after the treatment. THINNING then allows the trees to grow faster (and have an effect on mean DBH), and reduces the snag and DWD recruitment. The opening generated by the spacing is also favouring understory vegetation.

VARIABLE RETENTION: We assumed that retaining 30% of the stand volume at the final cut will ensure maintaining the biological legacies at the same level as after a natural disturbance. Consequently, there is no difference between NATURAL ORIGIN curves and VARIABLE RETENTION 30%. We assumed that VARIABLE RETENTION 15% allows maintaining 50% of the biological legacies usually observed in NATURAL ORIGIN stands. Moreover, MWFP has decided that VMS will be applied under VARIABLE RETENTION 15% for CD density stand, reducing the amount of herb, shrub and deciduous saplings at the beginning of the stand development.

CROP PLANS: Follow each density management plan of the CROP PLAN series, specifying the density of the single-species stand at every stand age.

2. BAP SHE Curves

2.1 Density of Dead Conifers 20+ (DENS_DC20+)

Definition

Density (ha^{-1}) of dead coniferous trees with a diameter ≥ 20 cm DBH. It includes trees with a DBH of 40 cm or greater.

Data

TSP: Diameter and height of all standing dead trees ≥ 10 cm DBH were measured within each TSP plot. In addition, three strip cruises (100 m long with a 10 m wide search radius) were used to increase sample size for dead standing trees ≥ 30 cm DBH.

PSP: Diameter and height of all standing dead trees ≥ 4 cm DBH were measured within each PSP plot. In addition, a 0.3 ha (30.9 m radius) circular plot (established using the PSP plot center) was used to increase sample size for dead standing trees ≥ 30 cm DBH.

Curve Development

The density of coniferous dead trees with a diameter ≥ 20 cm DBH was compiled for each plot using the appropriate plot multiplier to convert density to a per hectare basis. The sample plot database was used to generate the NATURAL ORIGIN stand curve. Observation of the data scatterplots suggested the shape of the curve (logistic, bell-shaped or Chapman-Richards function). As there were very few sampled stands younger than 50 years for many BAP strata (Table 6), we assumed, based on what we observed in strata Aw, Pl and Sw, that after a natural disturbance, many snags are available, as a legacy of the previous stand. They then turn into downed woody debris, provoking a drastic density reduction in snags. As the stand ages and self-thinning is becoming active, snag recruitment increases up to a certain maximum level. Then, depending on the BAP stratum, it either lowers down or maintains its density at a plateau.

Curves for the other stand origins and management regimes are all based on the NATURAL ORIGIN curves, but with some modifications. Under the MANAGE origin, it is assumed that there is no legacy from the previous stand (all trees have been harvested) and snags appears only when recruited later on from dying trees. THINNING is seen as a snag recruitment retardant as it usually removes moribund trees that were on their way to die and also reduces tree mortality. For the two levels of VARIABLE RETENTION, it was assumed that 30% of retention will allow a sufficient retention of green trees for allowing snags generation at about the same level as the NATURAL ORIGIN stand at the beginning while the 15% of retention would allow to retain 50% of the legacy observed at the beginning in the NATURAL ORIGIN stand.

2.2 Density of Dead Conifers 40+ (DENS_DC40)

Definition

Density (ha^{-1}) of dead coniferous trees with a diameter ≥ 40 cm DBH.

Data

Same as for DENS_DC20+.

Curve Development

Same methods used for DENS_DC20+, applied to dead coniferous trees with a DBH of ≥ 40 cm.

2.3 Density of Dead Deciduous 20+ (DENS_DD20+)

Definition

Density (ha^{-1}) of dead deciduous trees with a diameter ≥ 20 cm DBH. It includes trees with a DBH of 40 cm or greater.

Data

Same as for DENS_DC20+.

Curve Development

Same methods used for DENS_DC20+, applied to dead deciduous trees with a DBH of ≥ 20 cm.

2.4 Density of Dead Deciduous 40+ (DENS_DD40)

Definition

Density (ha^{-1}) of dead deciduous trees with a diameter ≥ 40 cm DBH.

Data

Same as for DENS_DC20+.

Curve Development

Same methods used for DENS_DC20+, applied to dead deciduous trees with a DBH of ≥ 40 cm.

2.5 Density of Live Conifers (DENS_LC0)

Definition

Density of live coniferous saplings (live trees ≥ 1.3 m in height and < 7.1 cm DBH).

Data

TSP: Diameter and height of all live trees ≥ 1.3 m in height and < 7.1 cm DBH were measured within a 3.99 m radius (50 m^2) sapling plot.

PSP: Diameter and height of all trees ≥ 1.3 m in height were measured within a 11.28 m radius (400 m^2) plot.

Curve Development

Density of live coniferous trees ≥ 1.3 m in height and < 7.1 cm DBH was calculated for each plot, then converted to a per hectare estimate using appropriate plot multipliers.

Sample plot data were used to create a relationship between density of coniferous saplings over time for each BAP stratum for NATURAL ORIGIN stands. Two general curve functions were used to fit the data: a negative exponential function for the deciduous species and a negative exponential function followed by a growth logistic function for the coniferous species. Such functions have been selected to fit the data because sapling density is assumed to be at its maximum just few years after the origin of the stand and then to decrease rapidly with the closing of the canopy. Spruces species may re-enter the stand later on when the stand reaches its break-up age and gaps are generated, allowing growth of pre-established understory seedlings.

Sapling density curves were the same for MANAGE (with and without THINNING), VR-30 and VR-15 origin as we assumed that retaining biological legacies should have very few effects on coniferous sapling density. CROP PLANS control, from the establishment of the stand, the sapling density at a low level.

2.6 Density of Live Deciduous (DENS_LD0)

Definition

Density of live deciduous saplings (live trees ≥ 1.3 m in height and < 7.1 cm DBH).

Data

Same as for DENS_LC0.

Curve Development

For the NATURAL ORIGIN and VARIABLE RETENTION 30% stands, the same methods used for DENS_LC0, have been applied to live deciduous saplings.

However, sapling density of stand under management regimes using VMS (MANAGE, VARIABLE RETENTION-15%, CROP PLAN) have a different curve as the VMS aim at reducing the density of deciduous saplings. Sapling density curves were the same for MANAGE (with and without THINNING), VR-30 and VR-15 origin as we assumed that retaining biological legacies should have very few effects on deciduous sapling density. CROP PLANS eliminate deciduous saplings.

2.7 Downed Woody Debris (DWD_Vol)

Definition

Volume (m^3/ha) of dead woody material (DWD) ≥ 10 cm in diameter that is not rooted in the ground.

Data

TSP: Three 30-m line transects were laid out to form an equilateral triangle with its apex at the center of the TSP plot. The diameter of all DWD ≥ 10 cm in diameter at the point of intersection with the line transect was measured.

PSP: Three 30-m line transects were laid out to form an equilateral triangle with its apex at the center of the TSP plot. The diameter of all DWD ≥ 7.5 cm in diameter at the point of intersection with the line transect was measured.

Curve Development

Line transect data were converted to volume per hectare estimates using standard formulae for volume estimation using De Vries's formula (De Vries 1974). Only DWD ≥ 10 cm were included in volume estimates. Plot data were used for developing stand with NATURAL ORIGIN curve. Based on the work completed by Hély et al. (2000), we recognised three DWD recruitment phases along the development of a stand originating from a natural disturbance. Following a disturbance, a lot of trees are falling on the ground, generating a first burst of DWD. DWD slowly decompose and very little new debris is added until the self-thinning phase when many small trees that can not compete are dying and falling down. Such self-thinning is more important in CD density stands than in AB density stands. Finally, the DWD pool is again populated by new trees during stand break-up. Generated scatter plots were clearly showing these three phases for many BAP strata and we then forced the DWD curves to follow such patterns for the NATURAL ORIGIN curves.

We assumed that 30% VARIABLE RETENTION was maintaining enough trees and snags after the final cut to generate the same amount of DWD as observed in the sample plots originating from natural disturbance. We suppose that retaining 15% of the standing material will reduce the amount of DWD by half until stand break-up, when compared to the NATURAL ORIGIN-VR30% curve, and then will slowly join the NATURAL ORIGIN-VR30% curve. The same pattern was used for the MANAGE regime but with much less pronounced recruitment phases; the stand originating from a clearcut without any retention will reduce the amount of DWD by four until stand break-up, when compared to the NATURAL ORIGIN-VR30% curve, and then will slowly join the NATURAL ORIGIN-VR30% curve. THINNING is assumed to reduce the recruitment of DWD after self-thinning and to retard the recruitment during and after stand break-up.

2.8 Mean DBH

Definition

Average tree diameter at breast height (DBH) regardless of species, for all trees ≥ 7.1 cm DBH.

Data

TSP: Diameter of live trees ≥ 7.1 cm DBH was measured within a larger plot, from 100 to 400 m^2 in size (5.64 to 11.28 m radius) depending on AVI cover type.

PSP: All trees 1.3 m in height and greater were sampled within a 400 m^2 (11.28 m radius) plot.

Curve Development

For the NATURAL ORIGIN curves, average DBH was calculated for each sample plot and then summarised by decade by BAP stratum. We did not observe significant difference between AB and CD density stands and we assumed that the detected pattern would be the same for the two density classes. Under the NATURAL ORIGIN curve, mean DBH is high at the establishment of the stand because of retained green trees but it is rapidly declining with the death of them and the arrival of small trees. We then observe a continuous increase until complete stand maturity. During the following period and stand break-up, mean DBH is then reduced due to a second arrival of small stems and reaches a plateau.

Under MANAGE, mean DBH starts from 0 and increases until it joins the NATURAL ORIGIN curve and slightly surpasses it for the rest of the time sequence. By doing so, we assume that early stand tending ensures bigger tree size. Such logic also applies to THINNING. When thinning is applied, mean DBH is increased. This is why the NATURAL ORIGIN WITH THINNING curve gets the highest mean DBH value after thinning. VARIABLE RETENTION has no effect on the Mean DBH curve and VR-30 and VR-15 follow the NATURAL ORIGIN curve. When CROP PLANS are applied, mean DBH follows the curve set by the CROP PLAN stand density management diagram of the series (MWFP 1999, McCready and Day 2000).

2.9 Old Growthness

Definition

The probability of a stand having “oldgrowthness” characteristics at any point in time. This is a continuous measure of old growth, which increases as the stand ages. Meant to measure old growth characteristics on the landbase.

Data

Not applicable.

Curve Development

At the midpoint of the mature seral stage, a stand is assigned a value of 0.5. This oldgrowthness value increases to 0.75 when the stand moves from the mature to the old seral stage. From there, the value increases at a steady rate for until it reaches a value of 1 (rate set such that a value of 1 is achieved 50 years after achievement of the old growth seral stage). The value remains at 1 until disturbance. After clearcutting, if no efforts are made to retain any biological legacies the oldgrowthness is zero. However, for NATURAL ORIGIN stands and for 30% VARIABLE RETENTION origin stands, it is recognised that some oldgrowthness value is maintained for the first 20 years (75% just after disturbance, 25% 10 years after disturbance, 0% 20 years after disturbance). Under VARIABLE RETENTION 15%, clearcutting with retaining 15% of the volume is considered not enough to generate some “oldgrowthness” value just after the harvest. Although for some ecologists/silviculturalists thinning is seen as a means to accelerate stand development to attain old growth characteristics because trees are getting bigger at a faster rate, here (to be on a conservative side), we assumed that thinning will be retarding the development of old growth stand features like snags and DWD and consequently, thinning is causing a delay in achieving oldgrowthness.

2.10 Basal Area

Definition

Total basal area of merchantable live trees (≥ 7.1 cm DBH), coniferous and deciduous trees combined.

Data

TSP: Diameter of live trees ≥ 7.1 cm DBH was measured within a larger plot, from 100 to 400 m^2 in size (5.64 to 11.28 m radius) depending on AVI cover type.

PSP: All trees 1.3 m in height and greater were sampled within a 400 m^2 (11.28 m radius) plot.

Curve Development

Basal area was calculated for each sampled tree and converted to basal area/ha using plot multipliers. Basal area was then summed for all live trees ($\geq$ 7.1 cm DBH) present within each plot. NATURAL ORIGIN curves were developed for each BAP strata and density classes using the sample plot database. The basal area curve starts after disturbance at a medium-high value, decreases rapidly, and then increases steadily until it reaches a maximum value during the mature stage. It then decreases slowly.

The curve for VARIABLE RETENTION 30% behaves like the NATURAL ORIGIN one. MANAGE stands allow an overall increase in basal area when the stand reaches the mature seral stage but clearcutting removes the trees observed at the beginning of the NATURAL ORIGIN curve. THINNING decreases basal area by 30%. Under CROP PLAN regimes, basal area follows the curve set by the stand density management diagram of the CROP PLAN series (MWFP 1999, McCready and Day 2000).

2.11 Free to Manoeuvre Flying Space

Definition

Proportion of area with CLEAR, POROUS/OBSTRUCTED or ENTANGLED free-to-manoeuvre flying space (FMFS). A qualitative description of the density of the subcanopy of the stand. It describes the ease with which a flying animal will move through the stand. CLEAR FMFS indicates well-spaced trees with no low branches (dead or alive) and no lower vegetation obstructing movement (“park-like”). POROUS/OBSTRUCTED FMFS indicates that many displacements would be required to avoid obstacles when reaching any point from another. ENTANGLED FMFS indicates abundant lower vegetation, with many lower branches present in such a way that it is practically impossible to fly under the canopy.

Data

TSP/PSP: At each plot location, the surrounding canopy characteristics are assessed to assign free-to-manoeuvre flying space into one of three categories: CLEAR, ENTANGLED or POROUS/OBSTRUCTED.

Curve Development

The proportion of each the three FMFS classes were computed for each BAP stratum, decade and density classes using the sample plot database in order to generate NATURAL ORIGIN curves.

Under VARIABLE RETENTION (30% and 15%), FMFS was deemed to behave like under NATURAL ORIGIN; only THINNING and CROP PLAN modify the proportion of the three classes. When THINNING is applied, POROUS/OBSTRUCTED FMFS decreases by 50% while CLEAR FMFS increases by 50%. Under CROP PLAN, FMFS is 100% ENTANGLED at the beginning of the development of the stand, then becomes 100% POROUS/OBSTRUCTED during the immature seral stage, and finally gets to 100% CLEAR during the last years of the rotation.

2.12 Herbs

Definition

The percentage of the forest floor covered by the different types of herb (large-leaved, ferns& horsetails, graminoids). A complete list of all herb species and their associated herb group is presented in MWFP (2004) and in The Forestry Corp (1999).

Data

TSP: Record percent cover to the nearest 1% if less than 10%, and in 10% classes thereafter. Percent cover may not exceed 100% for any species group, but total % cover across all species groups cannot exceed 100% due to overlapping vegetation.

PSP: Record percent cover to the nearest 1% if less than 10%, and in 10% classes thereafter. Percent cover may not exceed 100% for any species group, but total % cover across all species groups cannot exceed 100% due to overlapping vegetation.

Curve Development

A curve was generated for the NATURAL ORIGIN to model the percent cover of each of the three herb groups (large-leaved, ferns and horsetails, graminoids) and of total herb as a function of basal area. By doing so, it is believed that light more than age or stand composition is driving herb cover importance, hence relates more to the stand density than to the BAP stratum.

Adjustments from the NATURAL ORIGIN curve were made to account for the application of the VMS treatment in MANAGE, CROP PLAN and VARIABLE RETENTION -15% and for the THINNING treatment. After application of VMS, herb cover curves were adjusted based on vegetation community transition (MWFP 2005). As vegetation community transitions were developed only for the first 10 years, it was then used for extrapolating the effect of the VMS on herbs for the next few decades. As THINNING is creating a sudden opening in the canopy and therefore reduces the basal area, it allows the herb cover to increase. It increases according to the relationships with basal area. Under CROP PLAN, it was simply assumed that herb cover would be carefully controlled in the beginning of the development of the stand and some low density will be observed after canopy closure.

2.13 Ground Lichen

Definition

The percentage of the forest floor covered by the ground lichen.

Data

TSP: Record percent cover to the nearest 1% if less than 10%, and in 10% classes thereafter.

PSP: Record percent cover to the nearest 1% if less than 10%, and in 10% classes thereafter.

Curve Development

A statistical model was developed to predict ground lichen cover as a function of basal area, proportion of conifer, and moisture and productivity (TPR) index of the stand from the AVI. With this model, ground lichen cover increases if the proportion of conifer is greater than 85%, is reduced if basal area increases and is modified according to the combination of moisture and TPR (***Equation 1***). For example, mesic and unproductive sites will have almost 5% more ground lichen than dry and unproductive sites (Table 8).

Equation 1

Ground lichen %=2.52 - 1.52*[%Con<85%]-0.03666*Basal area + Moist_tpr_modifier

Table 8. Ground lichen % cover modifier in the predictive model according to the moisture and the productivity (TPR) of the stand.

Moisture[1]_TPR[2]	Modifier
d_M	-0.561
d_U	-0.039
m_F	0.775
m_G	0.832
m_M	1.202
m_U	4.921
w_F	2.443
w_G	0.322
w_M	1.083
w_U	0

[1]d=dry; m=mesic; w=wet.

[2]F=fair; M=medium; G=good; U=unproductive.

As this model is not related to BAP Stratum nor stand age, no graphs are presented in the appendix.

2.14 Arboreal Lichen Index

Definition

A relative index expressing the amount of arboreal lichen in the stand.

Data

TSP: The amount of arboreal lichen present on each tree was recorded by assigning one of the following five codes to each tree: N:None, T:Trace, L:Low, M:Medium, H:High.

PSP: The amount of arboreal lichen present on each tree was recorded by assigning one of the following five codes to each tree: N:None, T:Trace, L:Low, M:Medium, H:High.

Curve Development

We assigned an arboreal lichen value of 0, 1, 2, 3, 4 for the codes N:None, T:Trace, L:Low, M:Medium, and H:High respectively. Then, for each tree, the arboreal lichen value was multiplied by the basal area of the tree. To account for the crown importance, it was then adjusted according to the crown development class (MWFP 2004) as the following: Class 1 (full crown), Class 2 (3 sides of the crown developed), Class 3 (2 sides of the crown developed) and a Class 4 (1 side of the crown developed) having a modifying value of 4, 3, 2 and 1 respectively. Therefore, a tree with an arboreal lichen code = **Low** and a basal area of **0.2** m^2ha^{-1}, and a crown class of 2 will have an arboreal lichen relative abundance value of 0.8 (2*0.2*2). Arboreal lichen relative abundance value of all trees has been summed for each plot and then has been converted to a per hectare estimate using appropriate plot multipliers.

A statistical model was then developed to predict the arboreal lichen relative abundance as a function of stand age by BAP stratum and by density class. As arboreal lichen is accumulating in the forest with time since disturbance (even a light fire will consume the lichen), we assumed that origin and tending treatments would have no effect on the arboreal lichen index, i.e., it is the same curve.

2.15 Shrubs

Definition

The percentage of the forest floor covered by different classes of shrubs (fruit-bearing or not) and different height layers (see Table 4). A complete list of all shrub species and their associated shrub group is presented in MWFP (2004) and in The Forestry Corp (1999).

Data[P3]

TSP: Percent shrub cover and average height was recorded for each shrub species within a 10 m^2 (1.78 m radius) circular plot located at TSP plot center.

PSP: High shrubs (all live shrubs ≥ 3 m in height) were sampled within a 10 m^2 (1.78 m radius) circular plot located at PSP plot center. Species, percent cover and average height were recorded for each species present within the cylinder. Shrubs did not need to originate within the cylinder; branches of shrubs extended into the cylinder were included in sampling. The sum of individual species percent covers could exceed 100% due to overlapping.

Curve Development

A curve was generated for the NATURAL ORIGIN to model the cover of each of the shrub group (Fruit-bearing, Shrub ≥ 0.2 m, Shrub < 1 m, Shrub ≥ 1 m, Shrub ≥ 2 m, willow, willow plus rose) and of total shrub as a function of basal area. As for the herb SHE models, it is believed that light more than age or stand composition is driving shrub cover importance, hence relates more to the stand density than to the BAP stratum. Shrub models were developed similarly to the herb SHE models. However, as shrub development is slower than herb, we put a time delay response to openings by using the average of basal area of the last 20 years. Therefore, for example, the increase generated by thinning would appear 10 to 20 years later for the shrub cover than it appears for the herb cover.

Adjustments from the NATURAL ORIGIN curve were made to account for the application of the VMS treatment in MANAGE, CROP PLAN and VARIABLE RETENTION -15% (CD density) and for the THINNING treatment. After application of VMS, shrub cover curves were reduced and slowly return afterward to the NATURAL ORIGIN curve. As THINNING is creating a sudden opening in the canopy and therefore reduces the basal area, it allows the shrub cover to increase. It increases according to the relationships with basal area. Under CROP PLAN, it was simply assumed that shrub cover would be carefully controlled in the beginning of the development of the stand and some low density will be observed after canopy closure.

2.16 Species Composition

Definition

The proportion of total basal area of a tree species (dbh $\geq$ 7.1 cm).

Data

Same as for BASAL AREA.

Curve Development

BAP needs to assign forest composition to future conditions of forest stands as BAP uses many biodiversity indicator models depending on the forest stand composition, like ecosystem diversity and habitat quality. To do so, BAP uses composition curves to assign species abundance at different ages, in relation to the DFMP yield stratum that the Timber Supply Analysis uses.

Composition evolution was assessed by completing regression analyses relating species basal area percentage with stand age. Linear and 2^{nd}-order polynomial regression analysis was performed using the CURVE FIT procedure in SPSS (SPSS Inc. 1999). A relationship was considered acceptable when α>=0.10 for the model (P(F)) and the parameters (P(T)).

These relationships were used to develop the composition curves for each BAP stratum, not distinguishing them by density class. When no linear or quadratic relationship was significant, we assumed the percentage of the species was constant across stand age. Composition curves were obtained by putting together all the percentage values estimated by the regressions and then standardizing their value to make sure that the sum equal 100%. Negative estimated values were set to 0. The model for each BAP stratum was developed to encompass a 200-years stand age gradient.

We did not make composition curves for VARIABLE RETENTION and MANAGE origins being different than the NATURAL ORIGIN ones. THINNING increased the proportion of the coniferous leading species of the BAP stratum. For example, thinning in the Pl_Aw BAP stratum will make the proportion of Pl greater afterwards. CROP PLAN are essentially single species stands with some very minor deciduous components at the beginning of the stand development.

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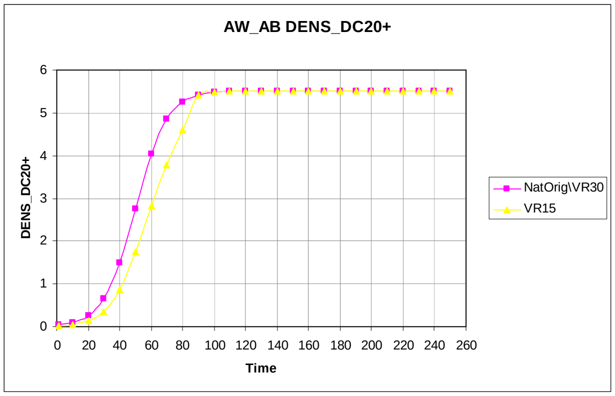
Appendix I SHE Curves

SHE curves were developed for selected strata anticipating the potential treatments that would be modeled in the Forecasting (Table 9). Strata codes are comprised of the BAP species strata prefix and density as a suffix. Low density represented by _AB and higher full density by _CD.

Table 9. BAP SHE curve listing by treatment type.

	Fire Origin		Managed				
Stratum	**Natural Stand**	**Commercial Thin**	**Clearcut**	**Clearcut/ VR 30%**	**Clearcut/ VR 15%**	**Crop Plan**[1]	**Commercial Thin**
Aw_AB	✓			✓	✓		
Aw_CD	✓		✓	✓	✓		
Pb_AB	✓			✓	✓		
Pb_CD	✓		✓	✓	✓		
Bw_AB	✓			✓			
Bw_CD	✓			✓			
AwPl_AB	✓			✓	✓		
AwPl_CD	✓		✓	✓	✓		
AwSwSb_AB	✓			✓	✓		
AwSwSb_CD	✓		✓	✓	✓		
Pb_Con_AB	✓			✓	✓		
Pb_Con_CD	✓		✓	✓	✓		
PlAw_AB	✓			✓	✓		
PlAw_CD	✓	✓	✓	✓	✓		
SwAw_AB	✓	✓		✓	✓		
SwAw_CD	✓	✓	✓	✓	✓		
Pl_AB	✓			✓	✓		
Pl_CD	✓	✓	✓	✓	✓	✓	
Lt_AB	✓			✓			
Lt_CD	✓			✓			
Sw_AB	✓	✓		✓	✓		
Sw_CD	✓	✓	✓	✓	✓	✓	
Sb_low_AB	✓			✓	✓		
Sb_low_CD	✓		✓	✓	✓		
Sb_Up_AB	✓			✓	✓		
Sb_Up_CD	✓	✓	✓	✓	✓	✓	✓

[1] Crop plan strata were divided by site index representing medium and good TPR.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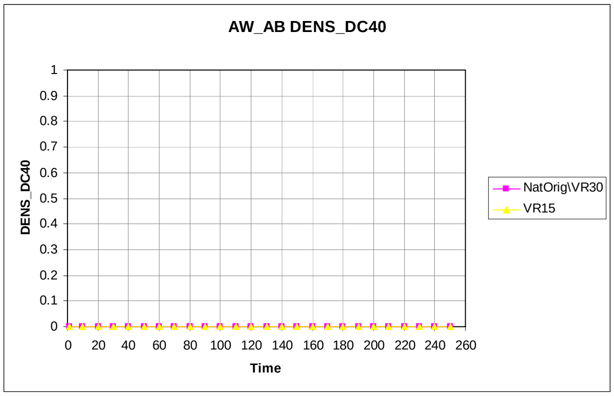
VR15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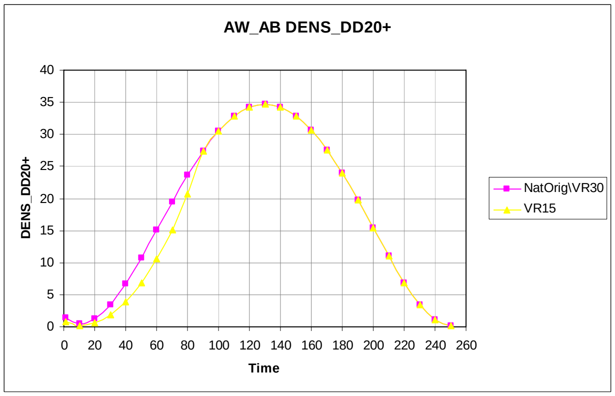
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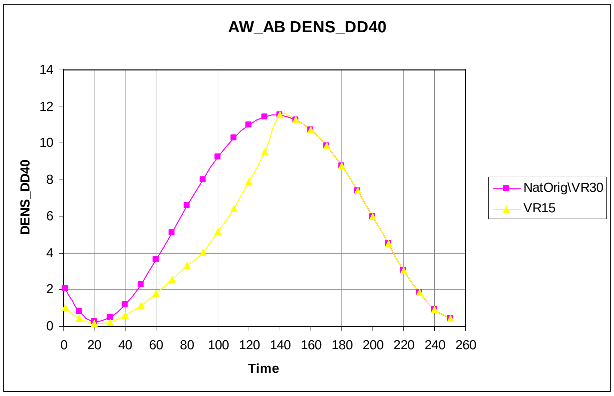
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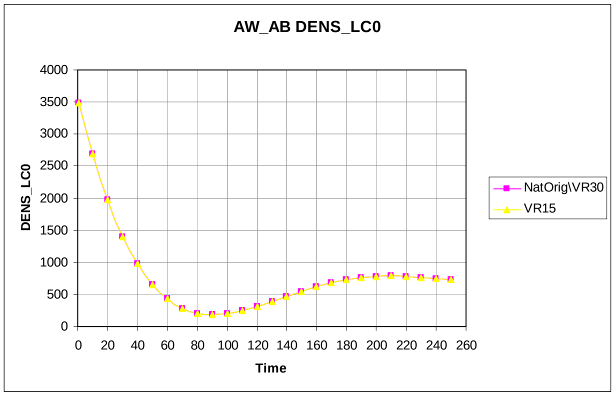
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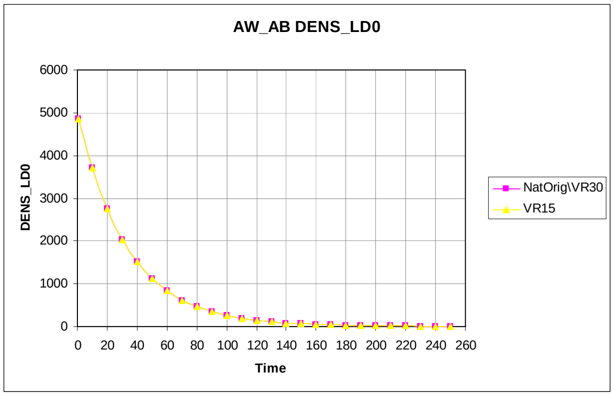
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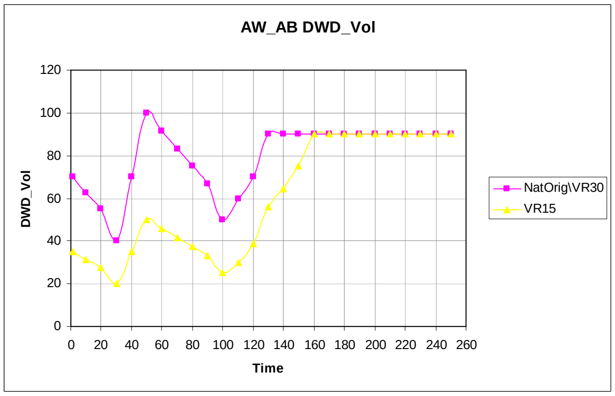
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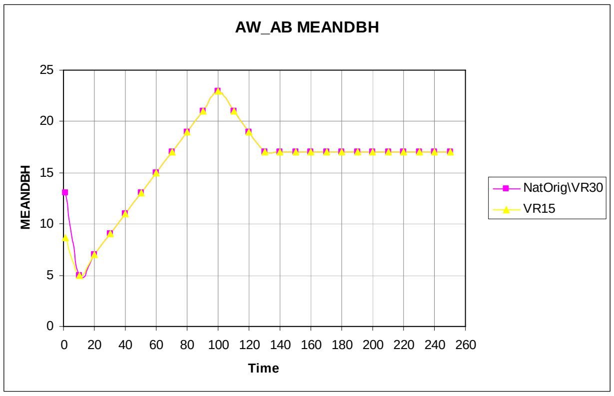
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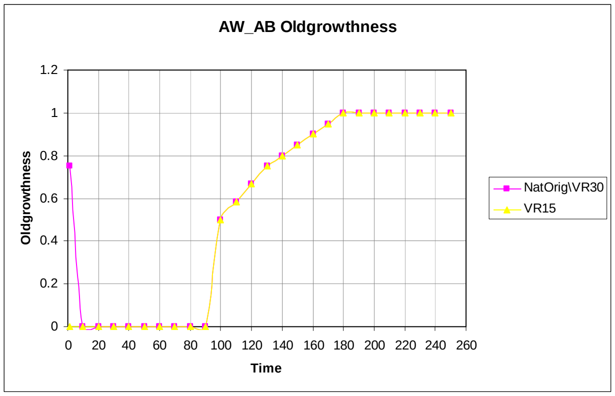
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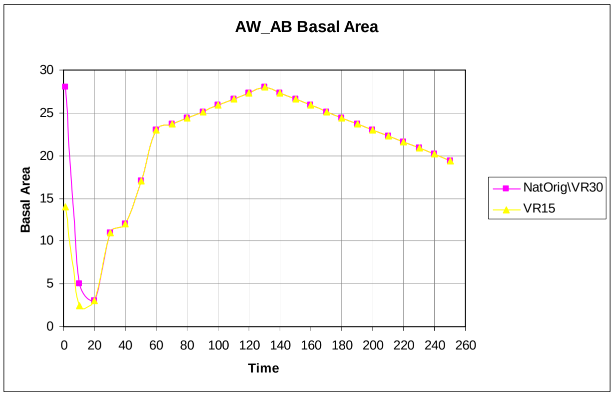
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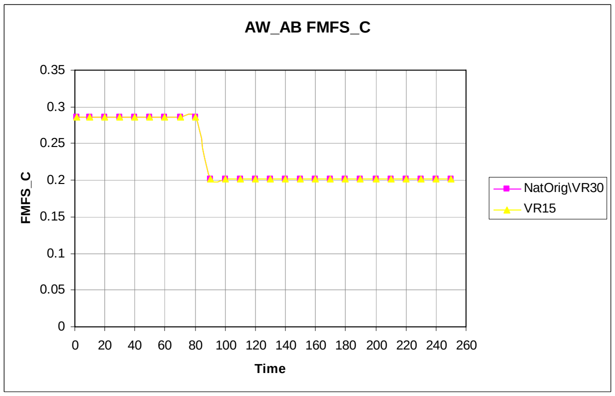
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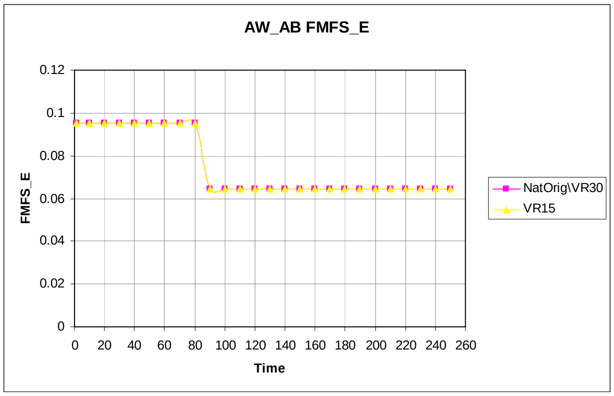
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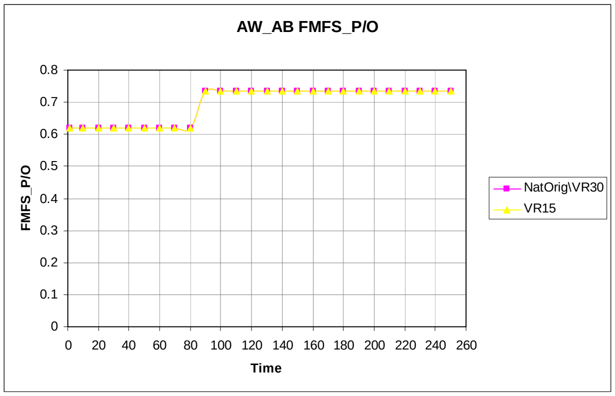
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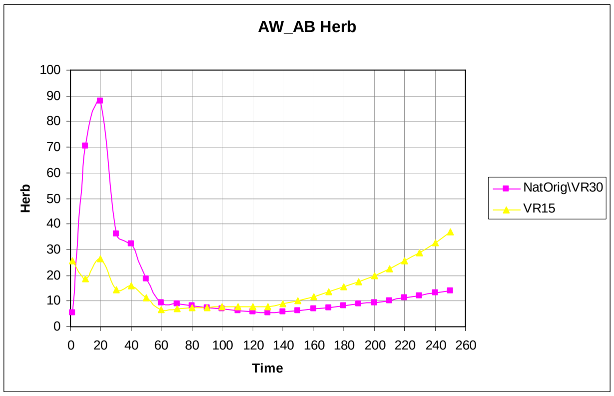
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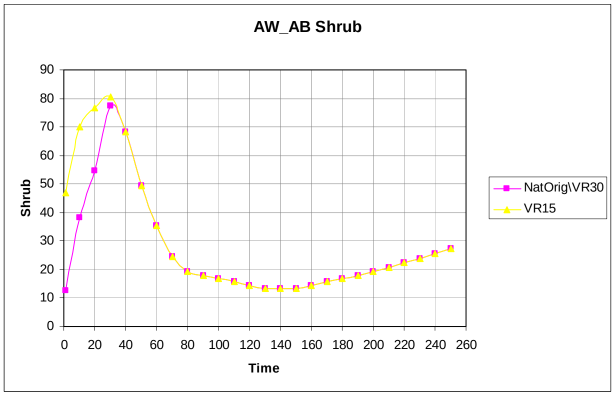
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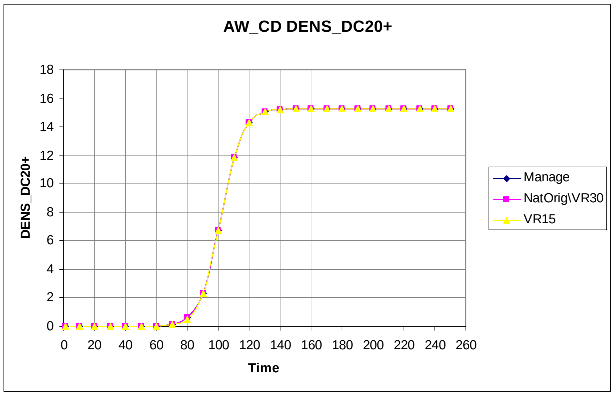
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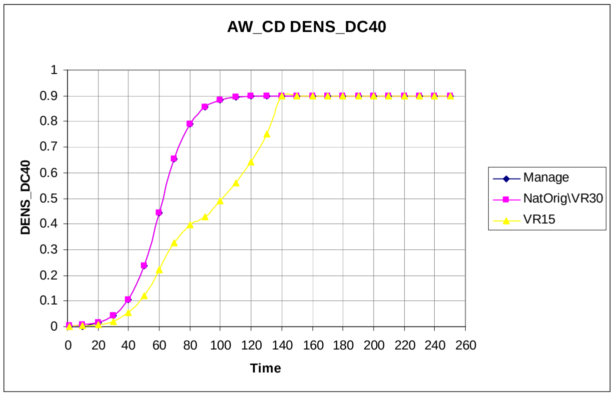
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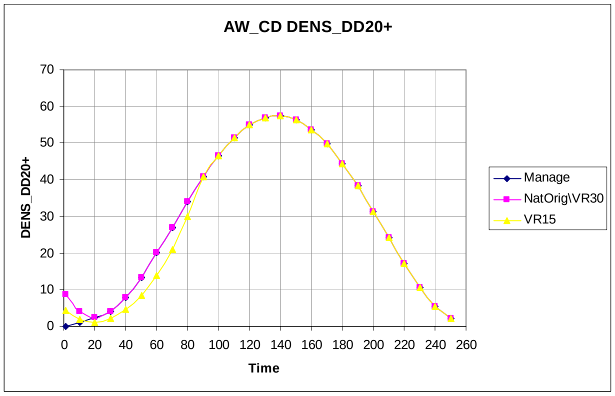
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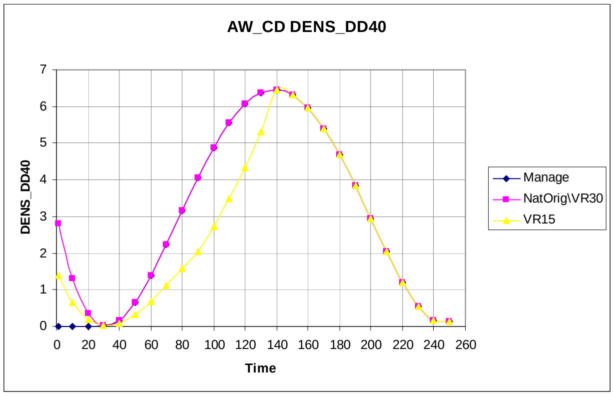
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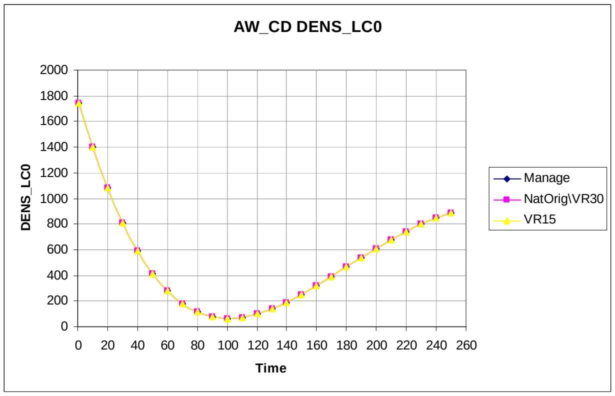
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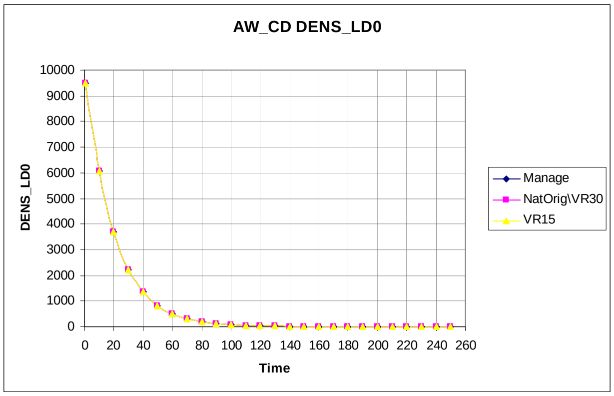
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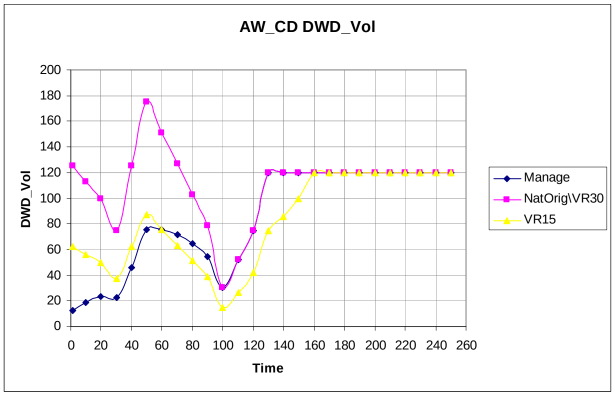
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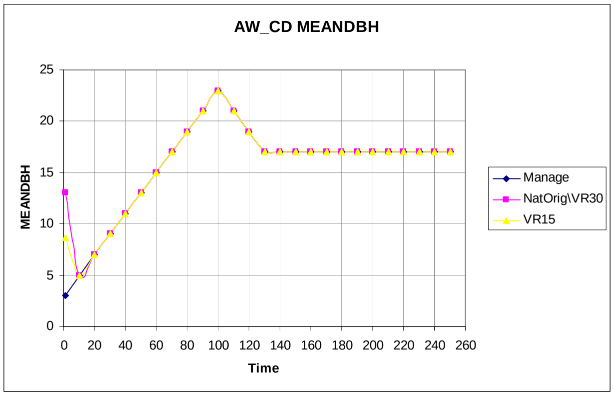
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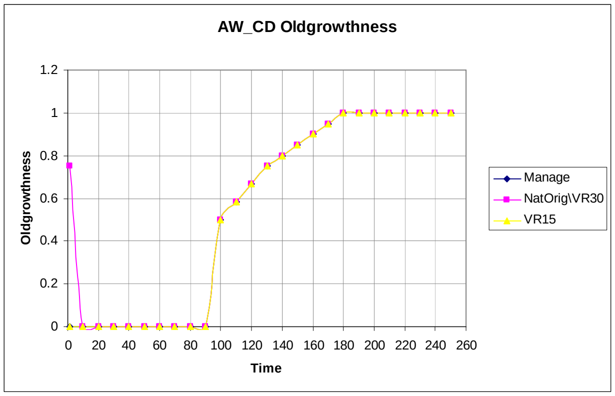
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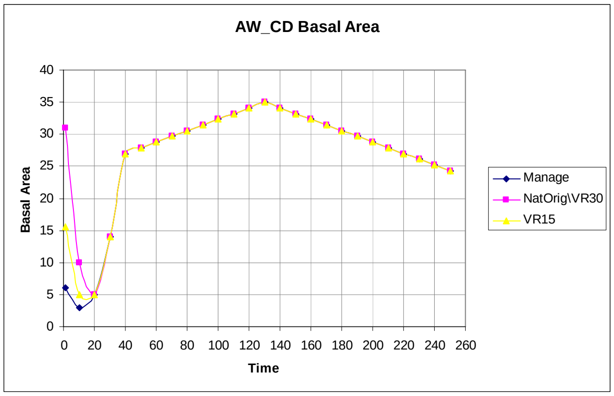
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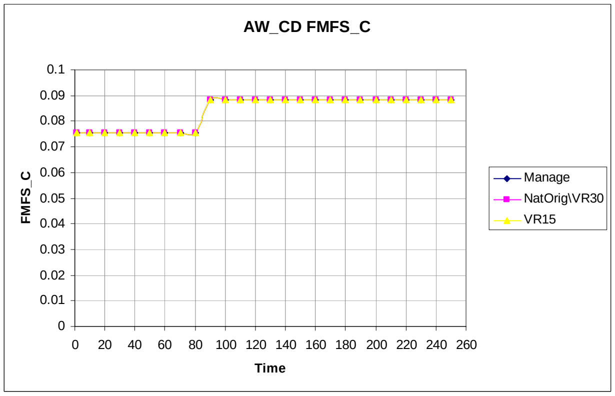
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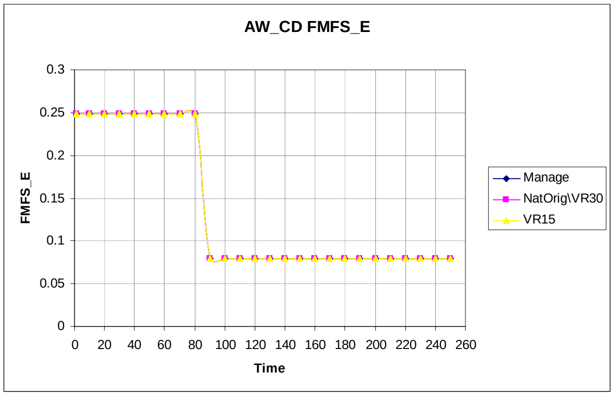
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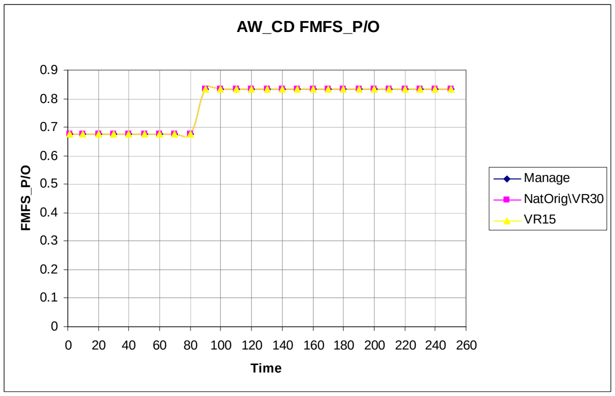
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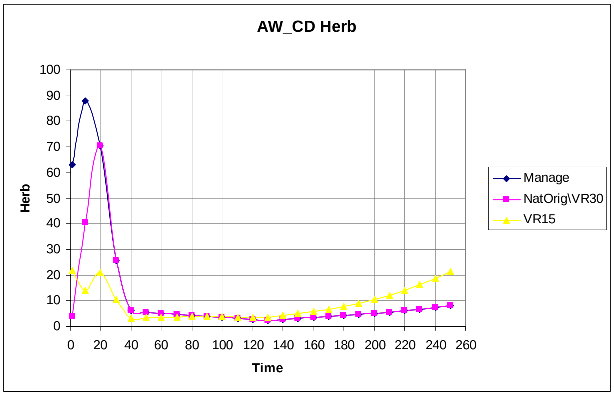
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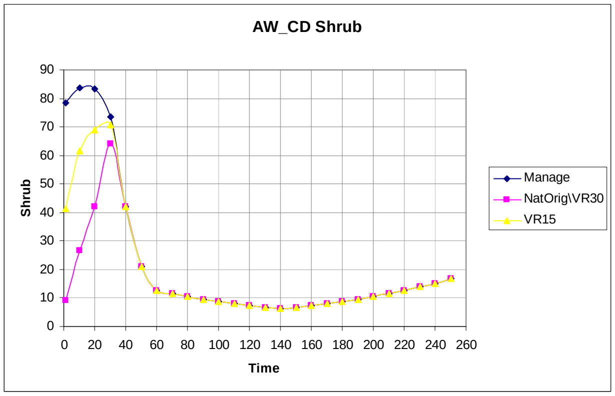
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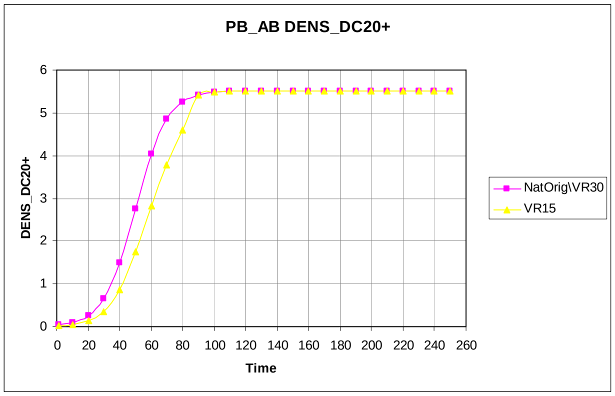
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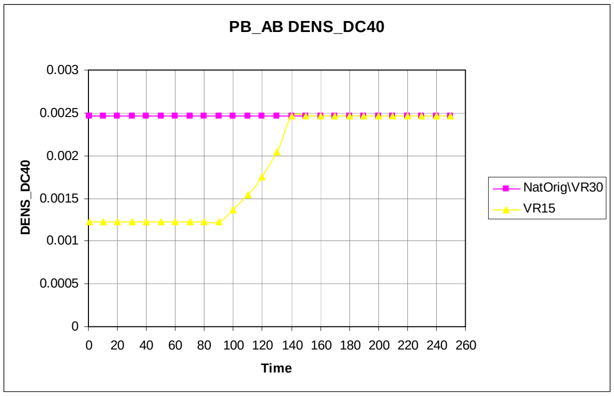
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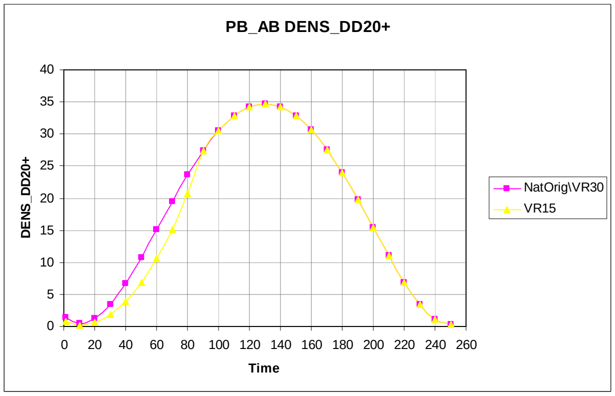
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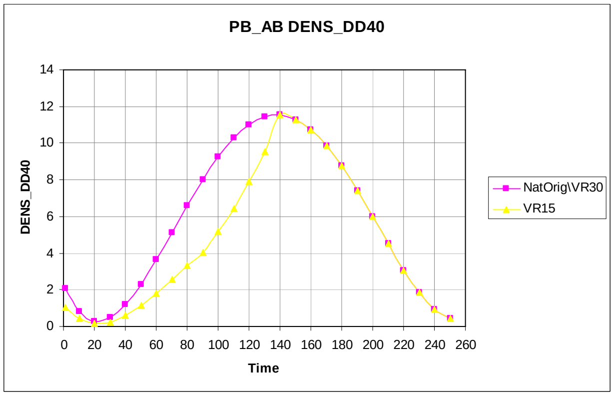
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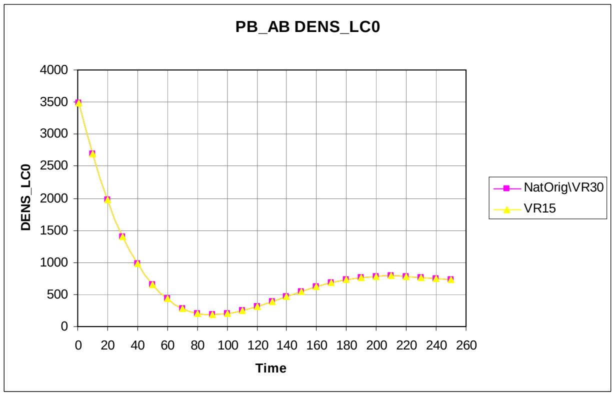
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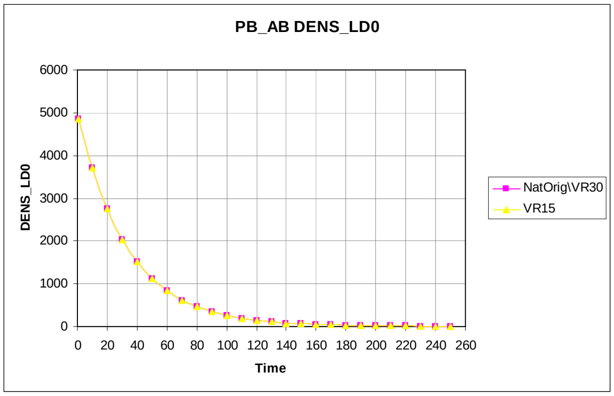
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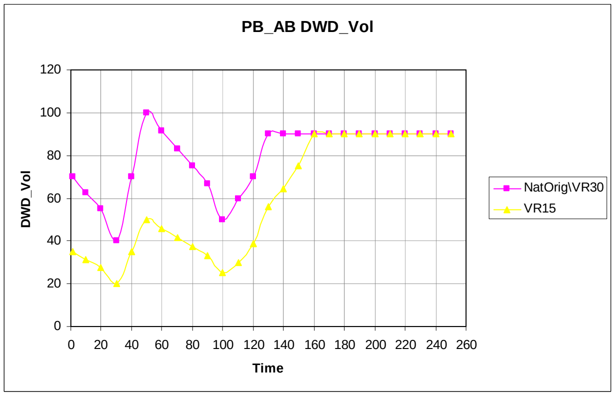
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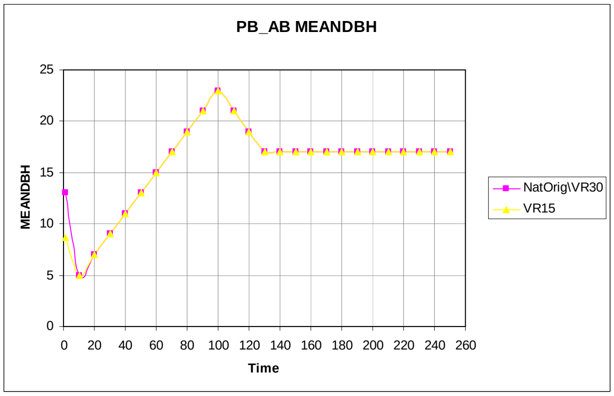
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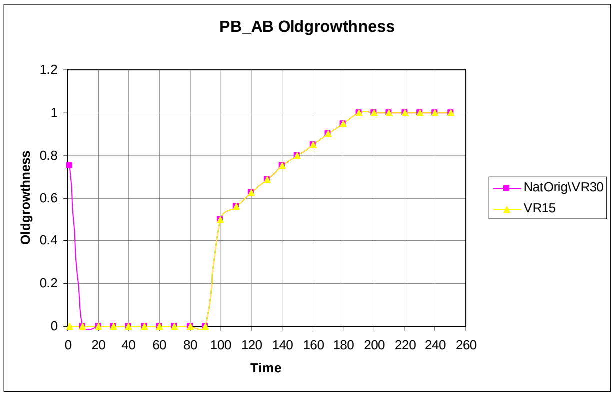
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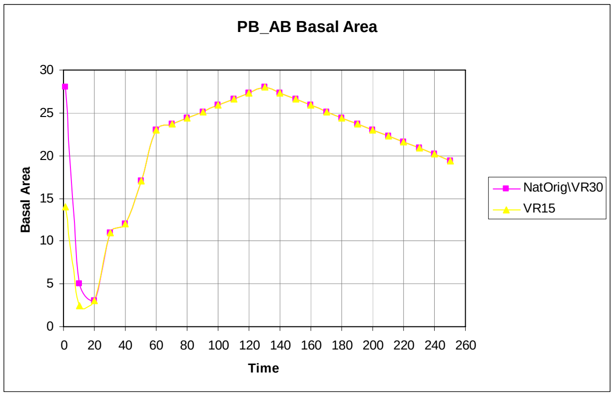
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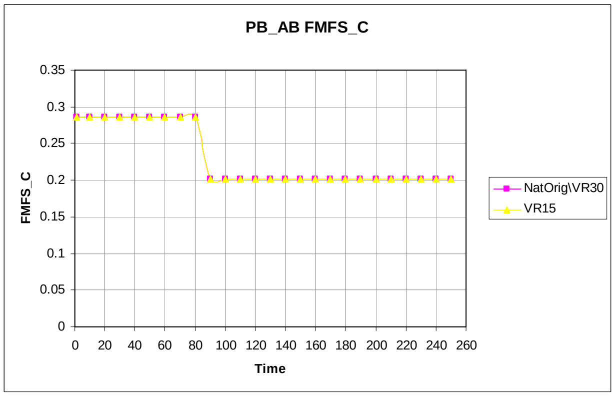
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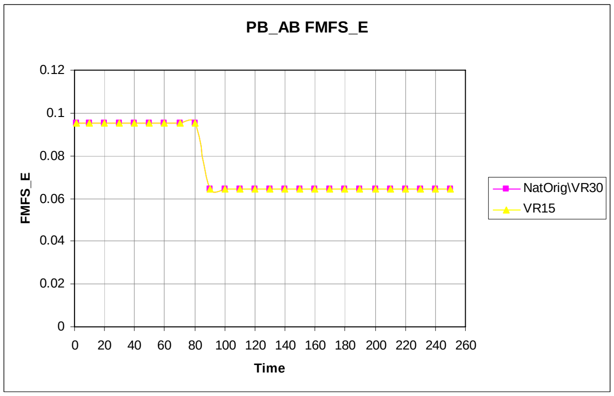
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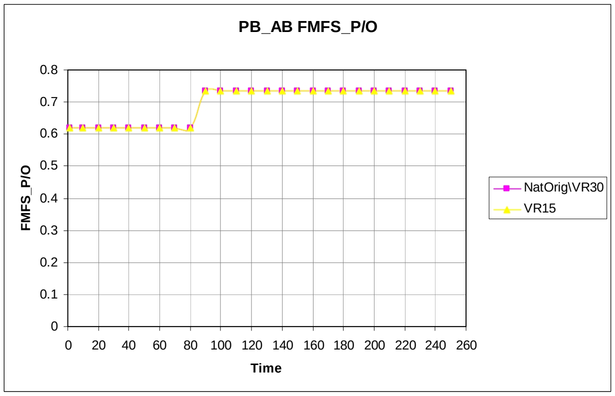
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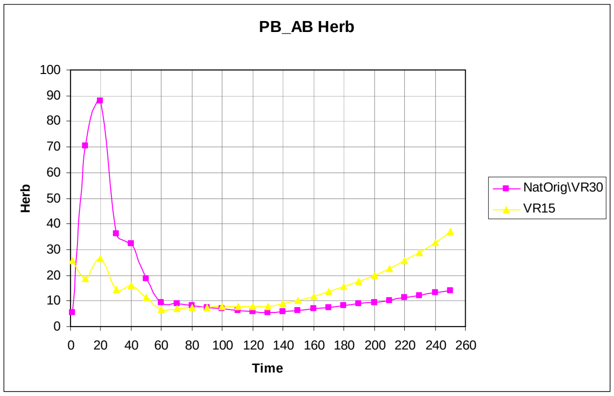
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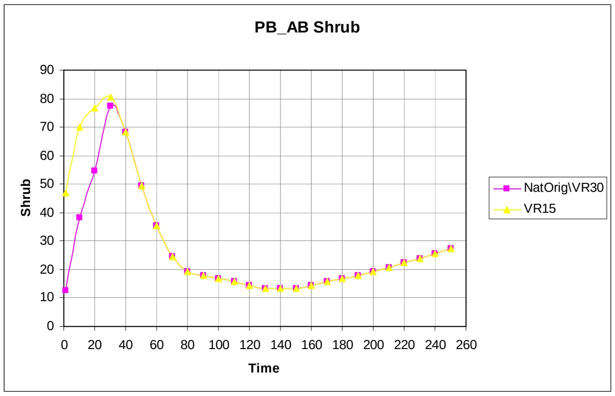
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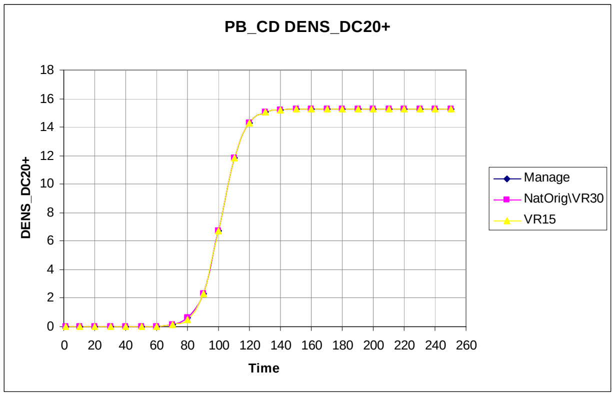
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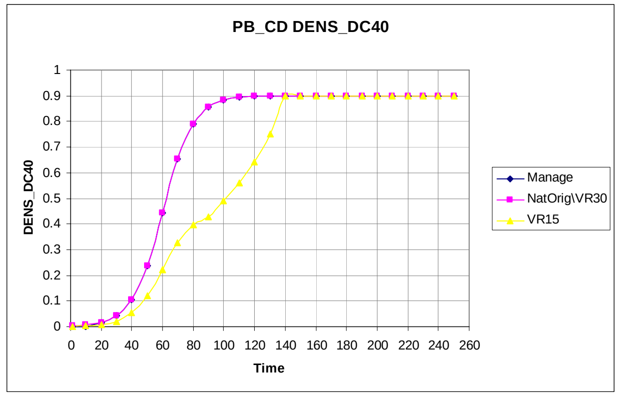
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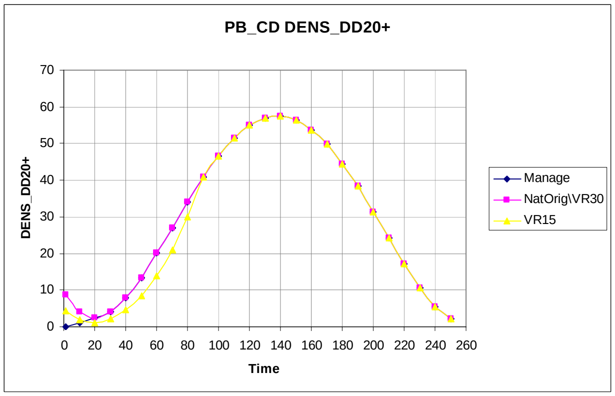
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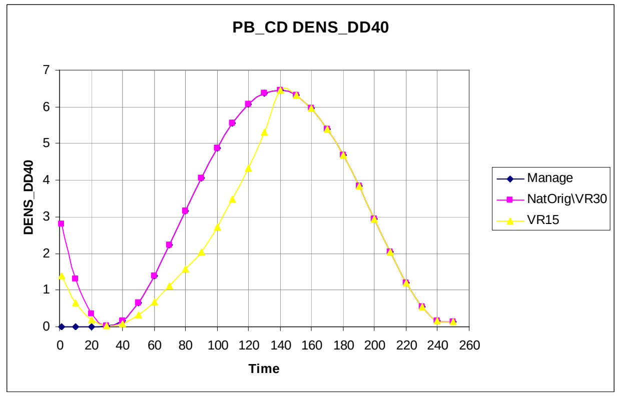
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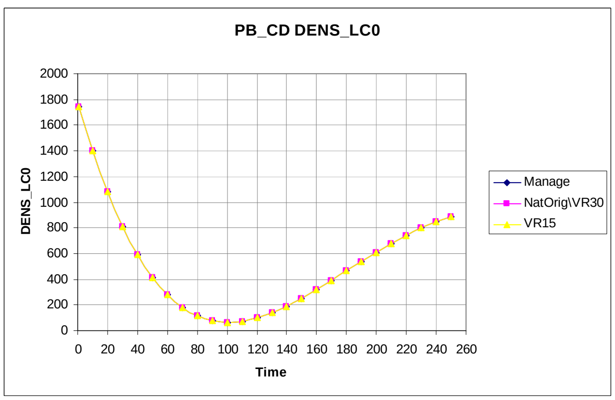
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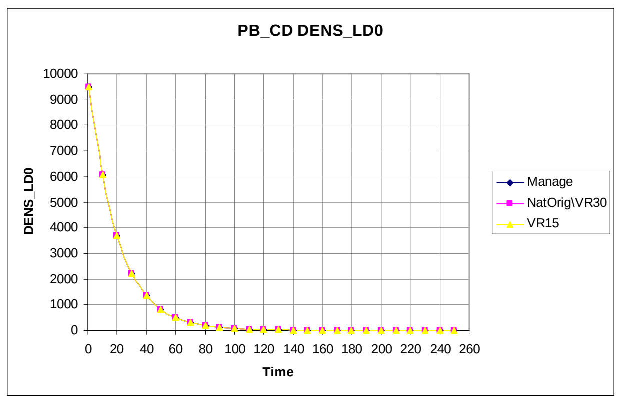
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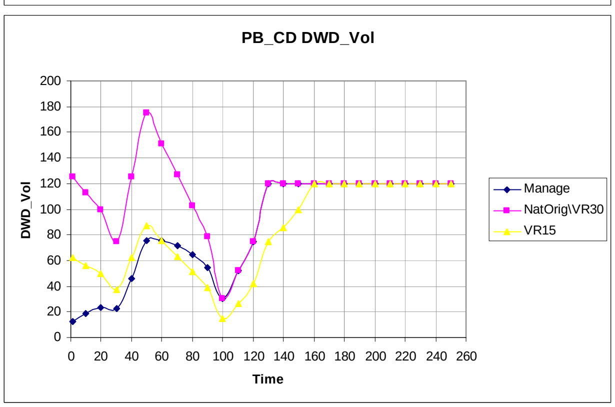
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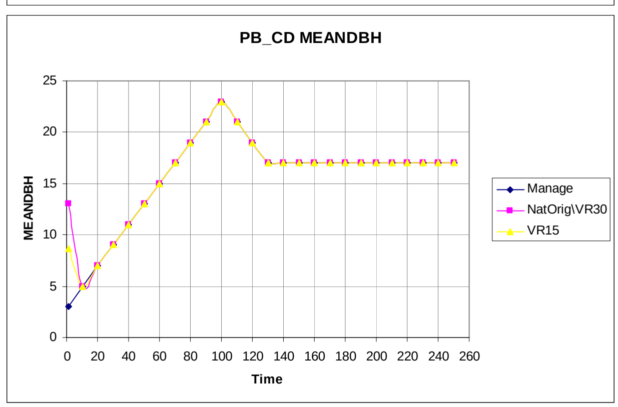
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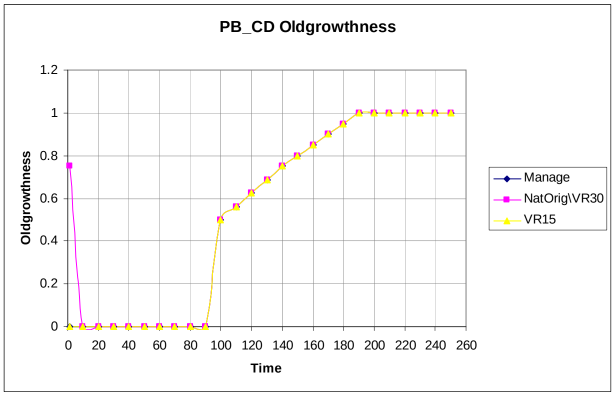
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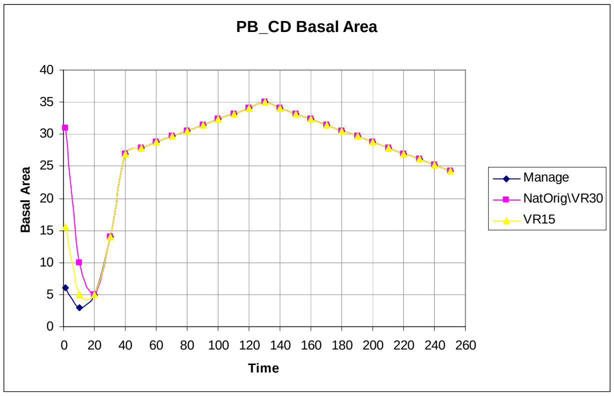
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Basal Area
Time
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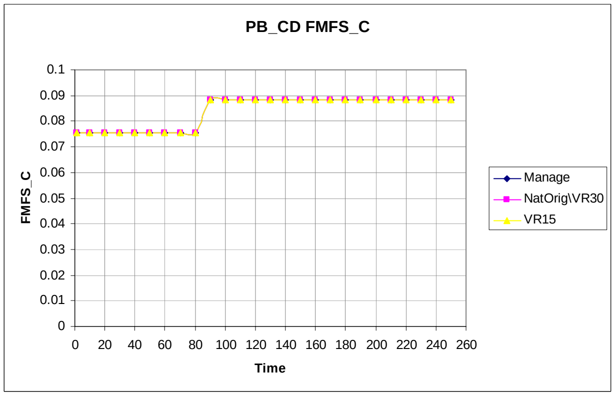
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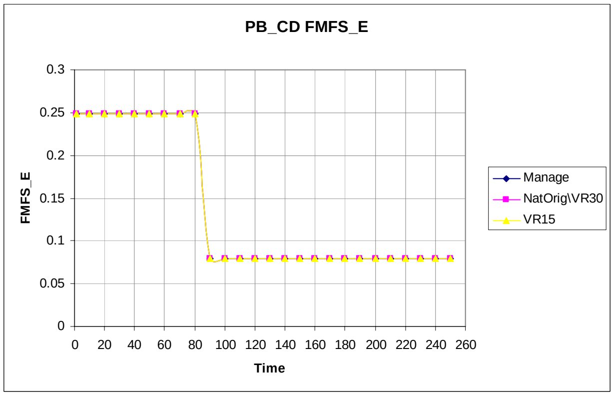
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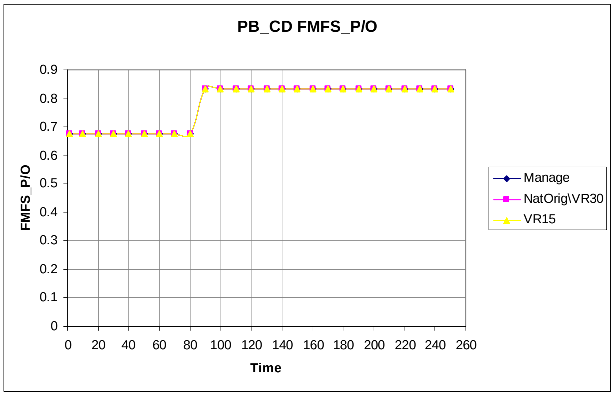
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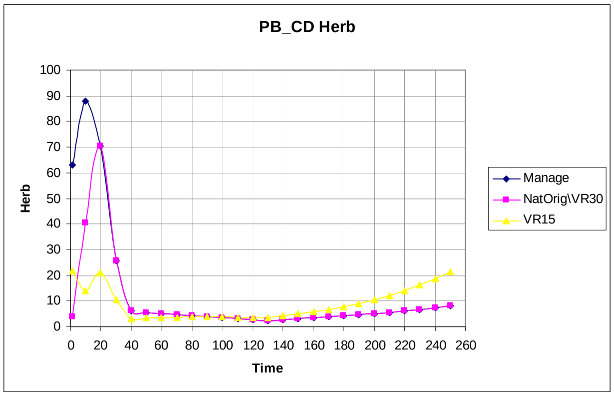
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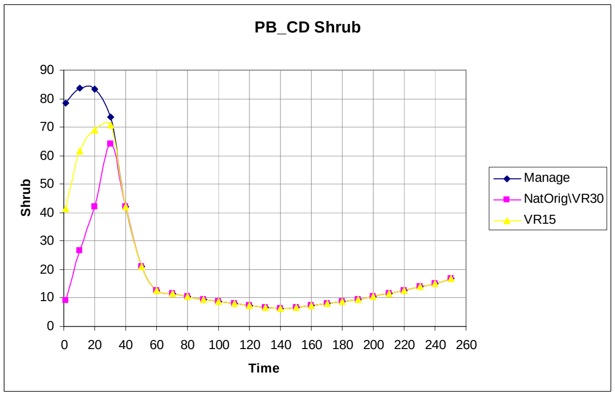
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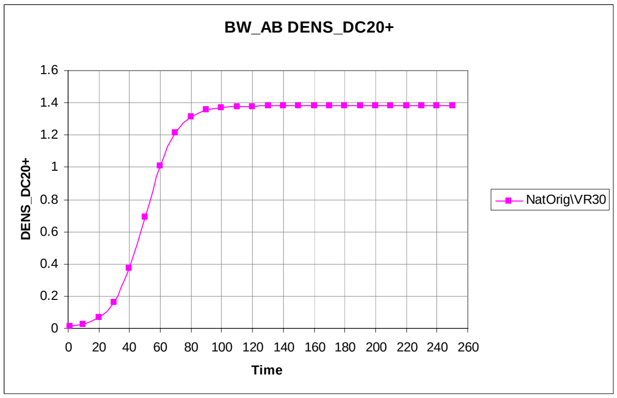
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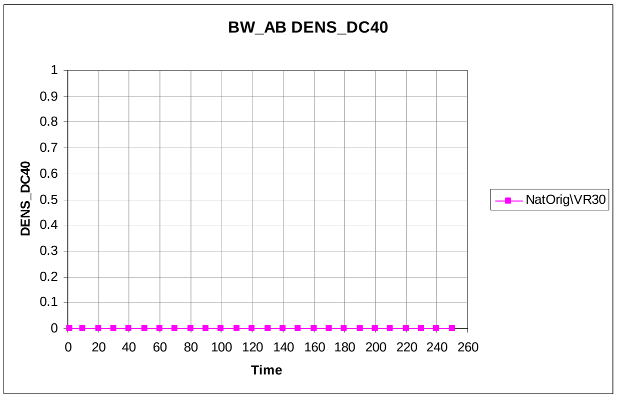
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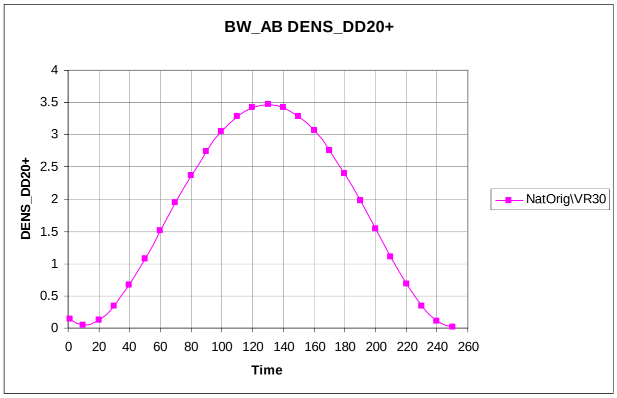
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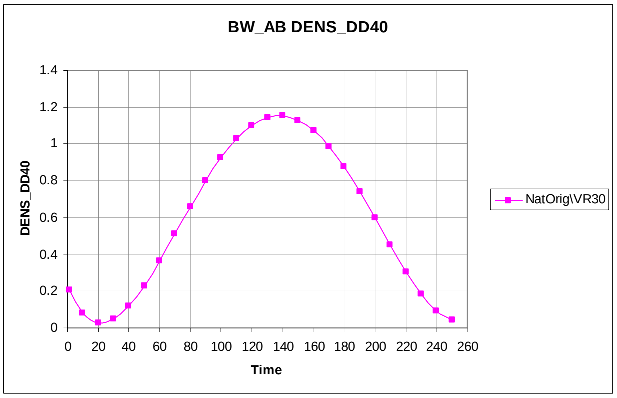
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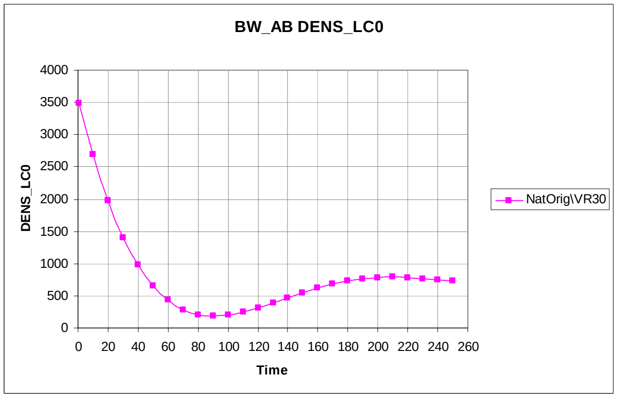
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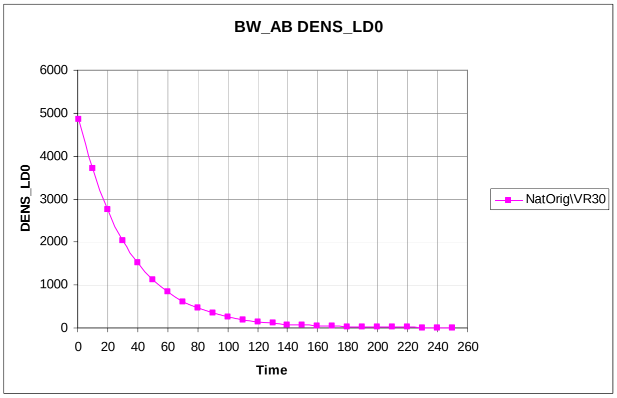
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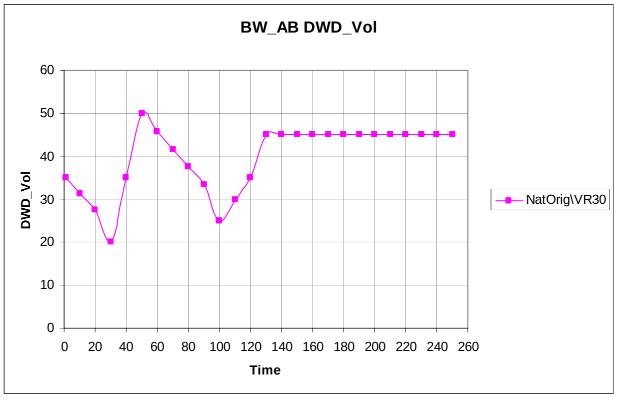
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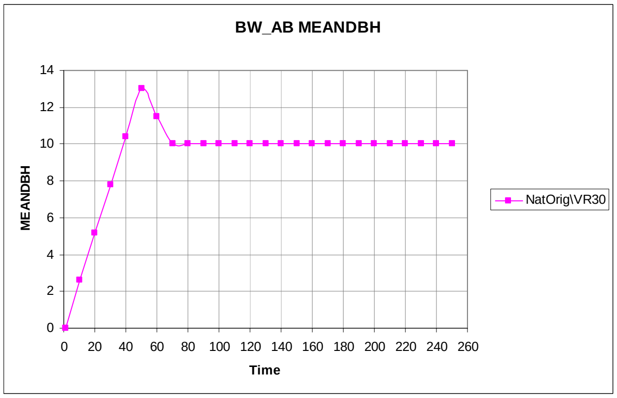
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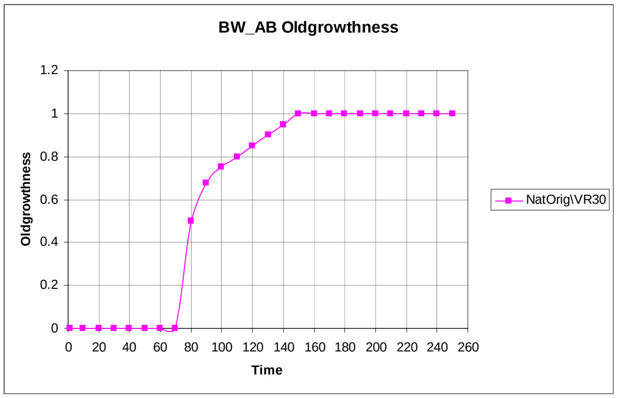
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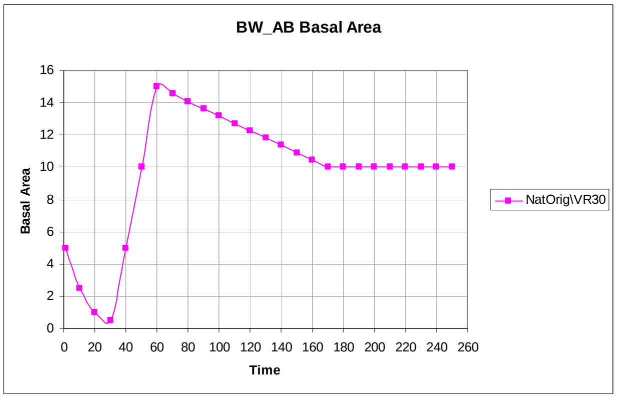
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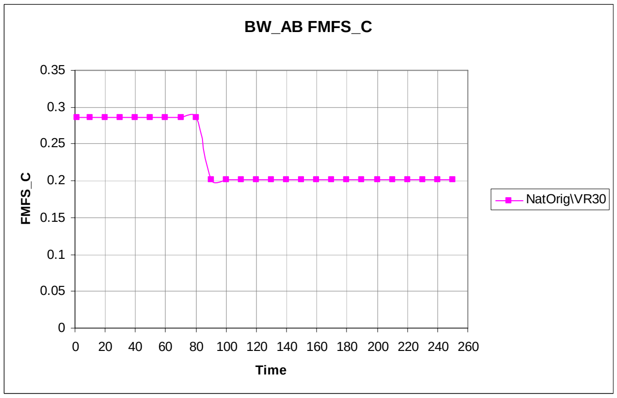
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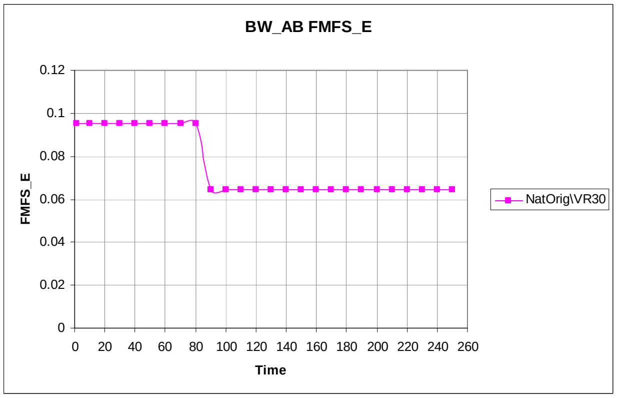
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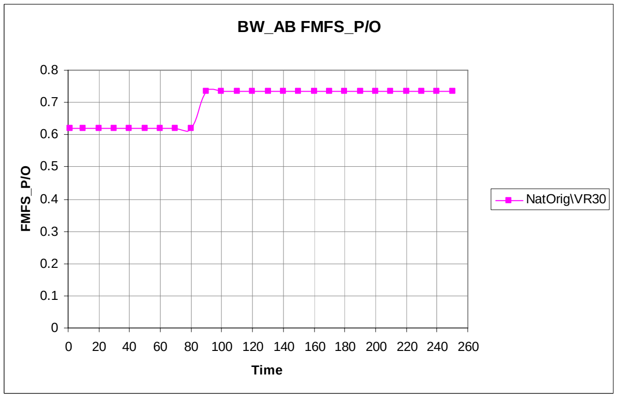
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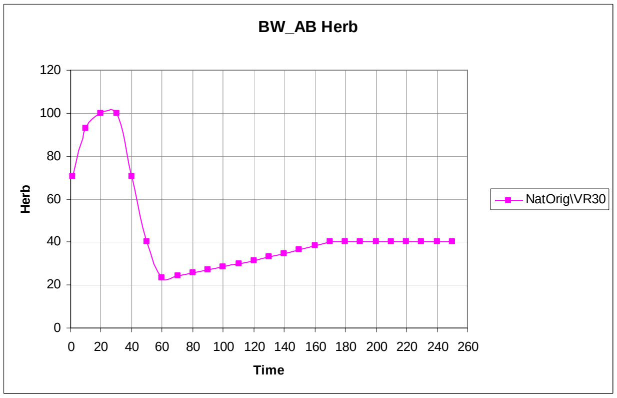
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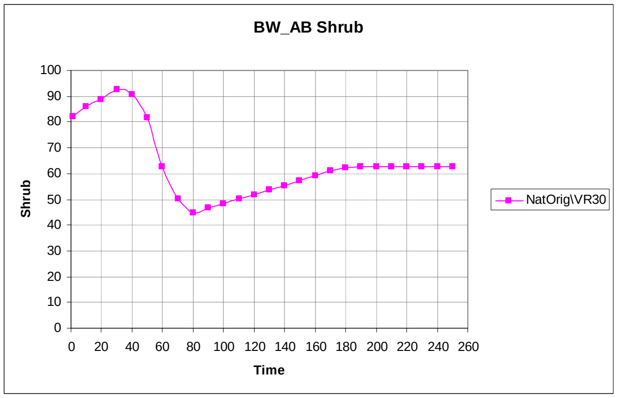
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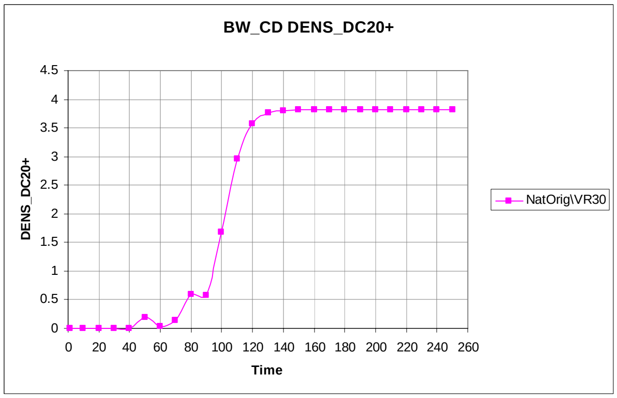
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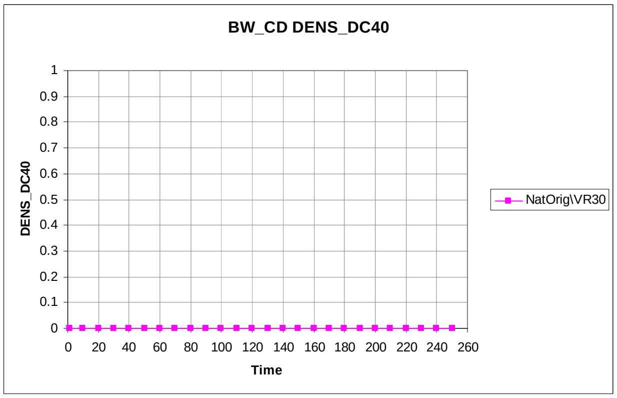
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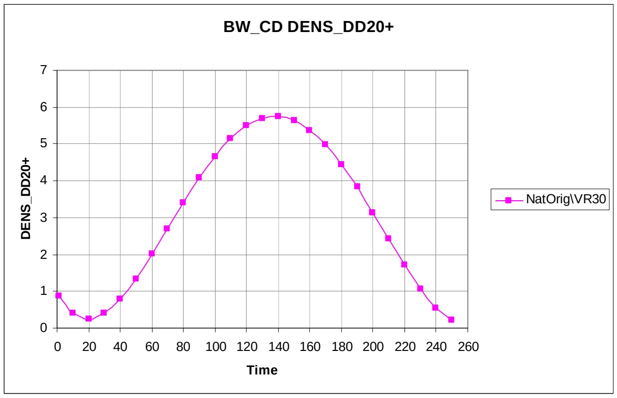
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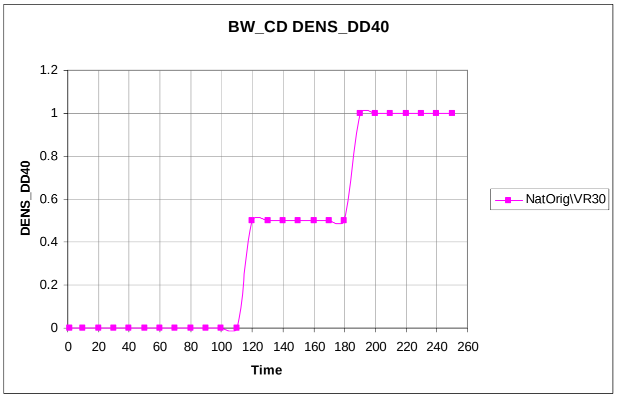
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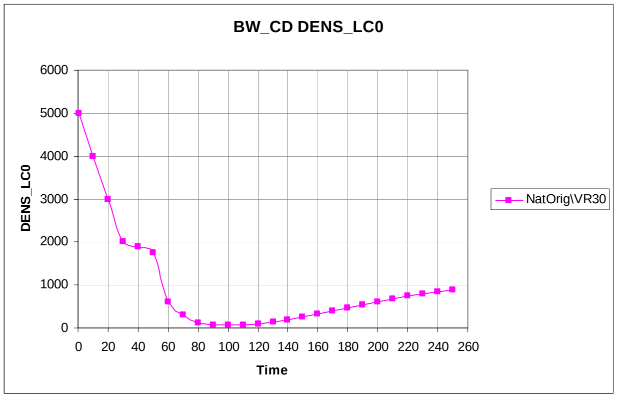
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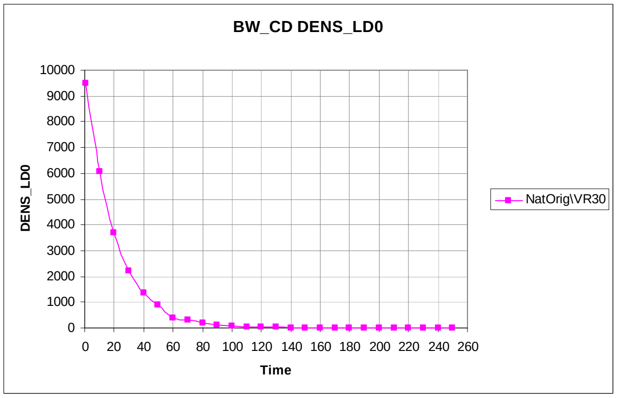
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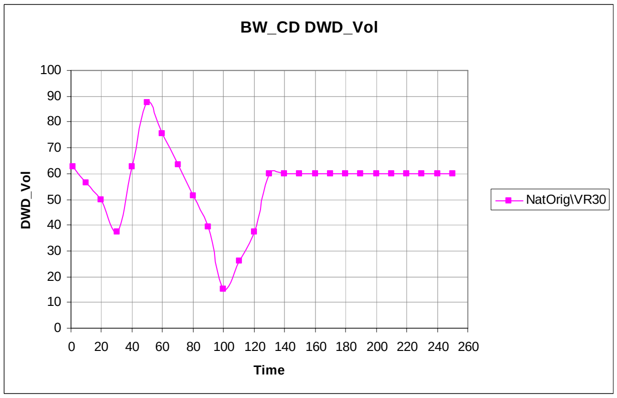
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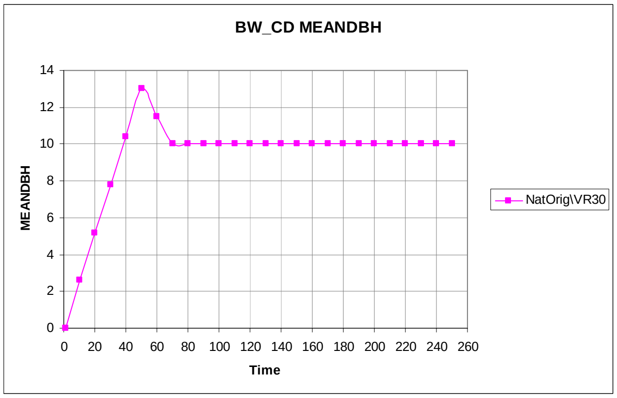
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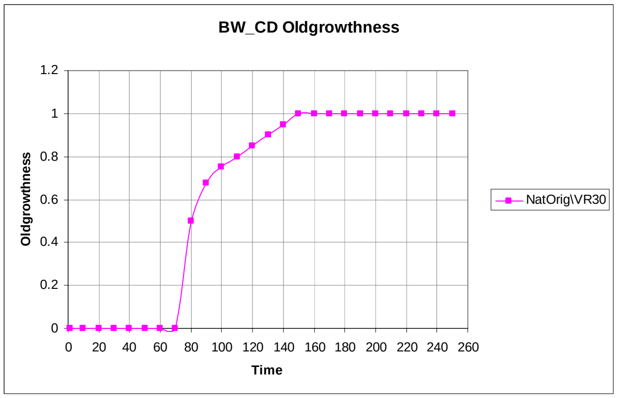
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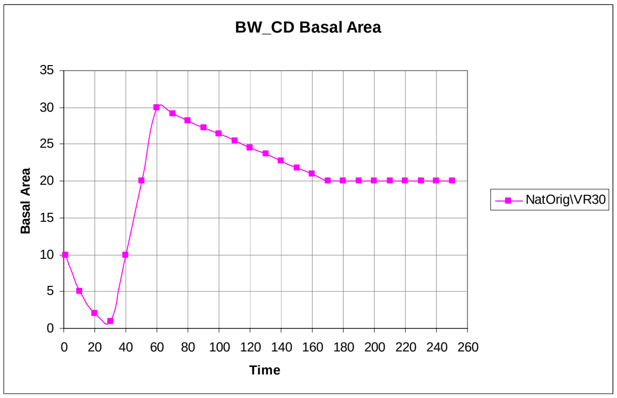
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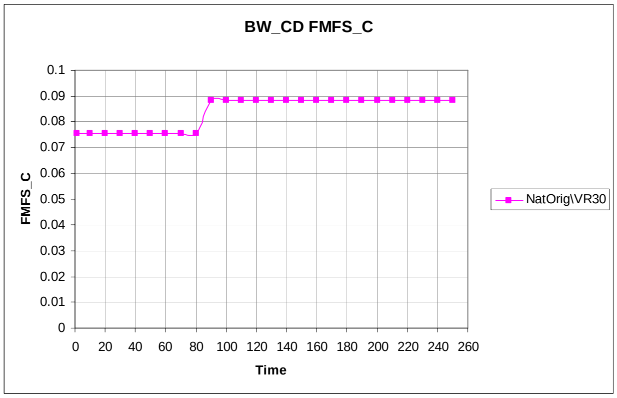
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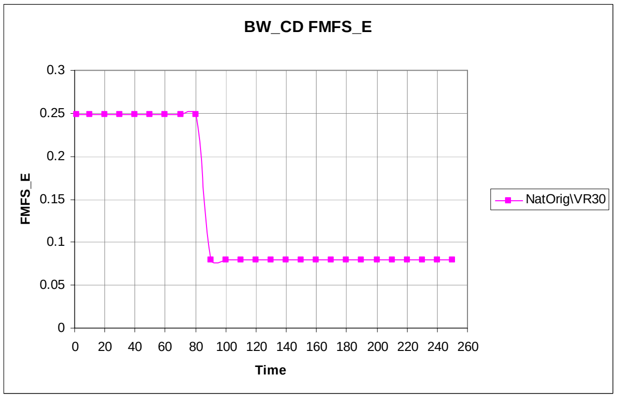
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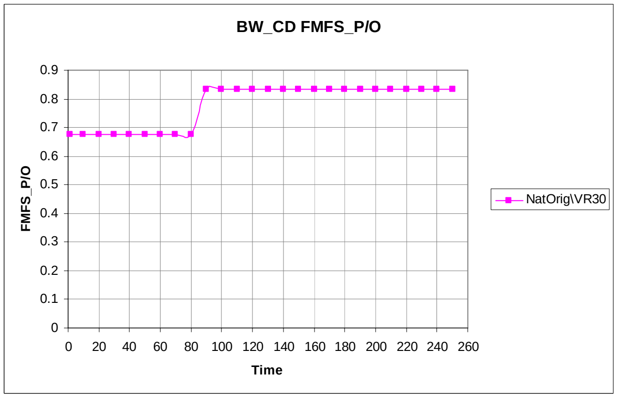
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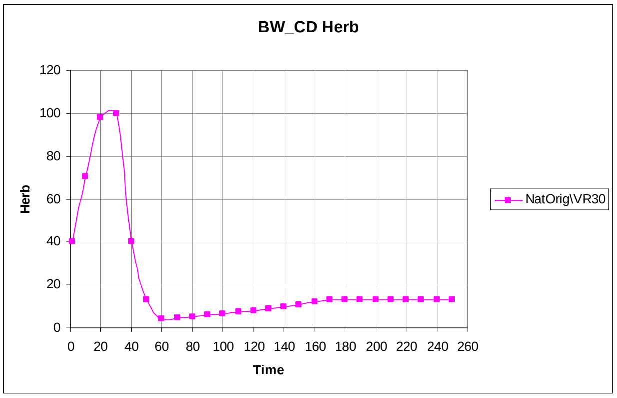
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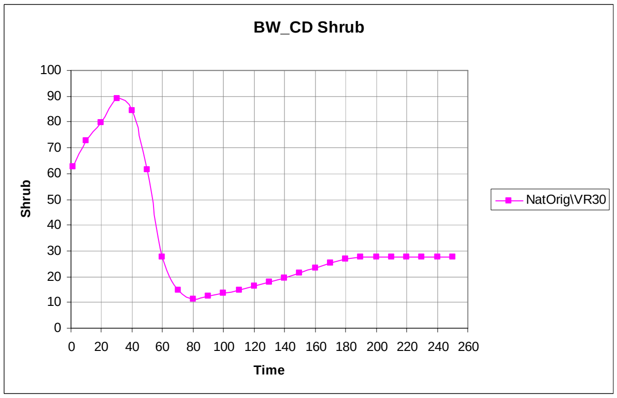
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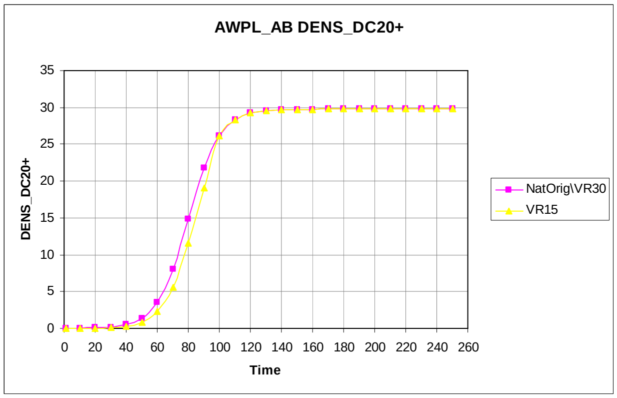
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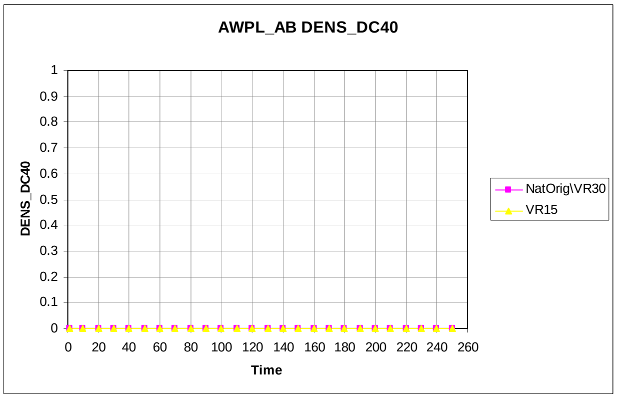
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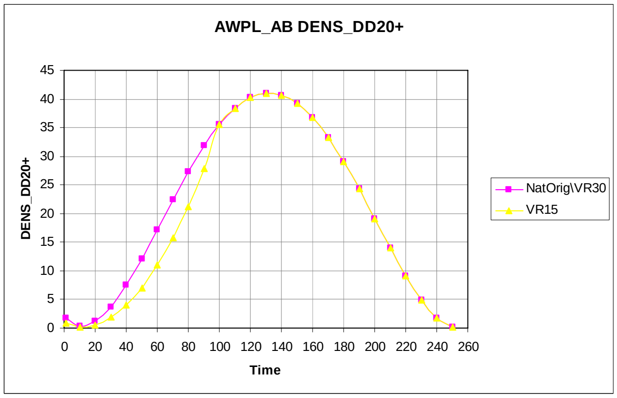
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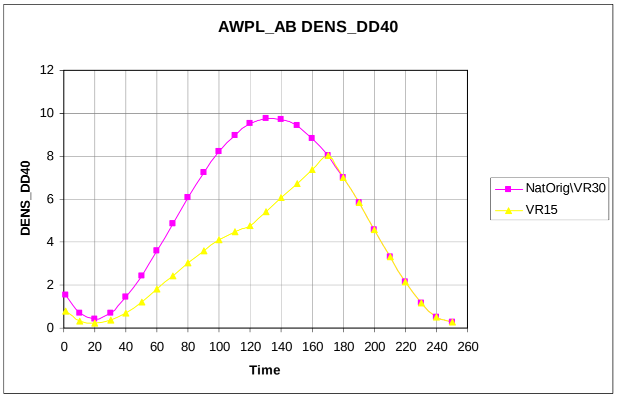
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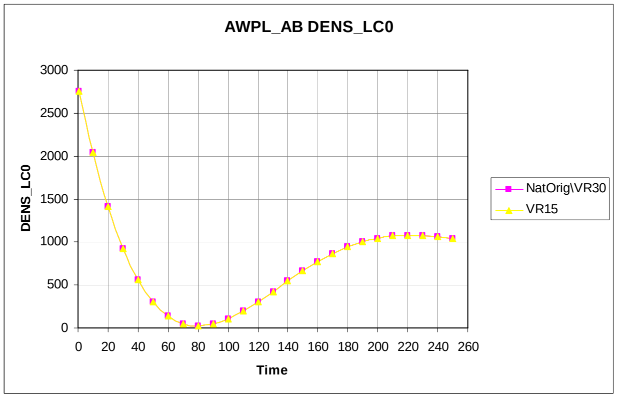
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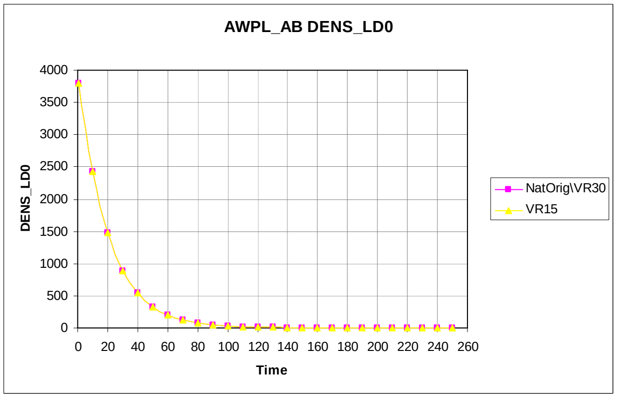
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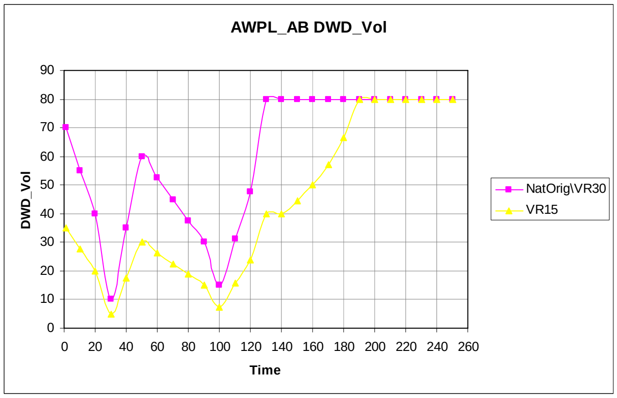
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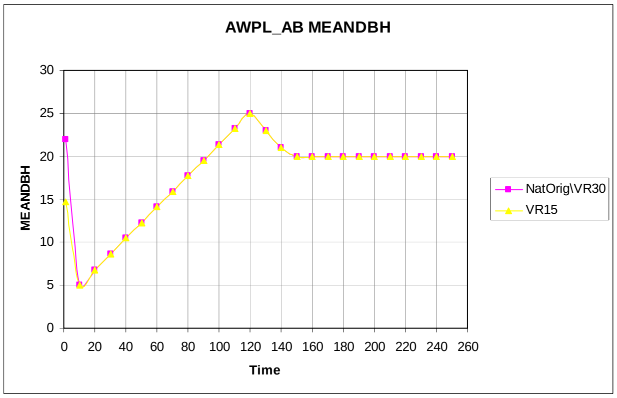
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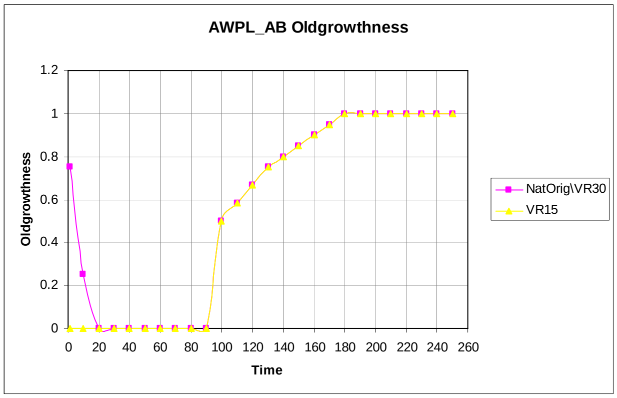
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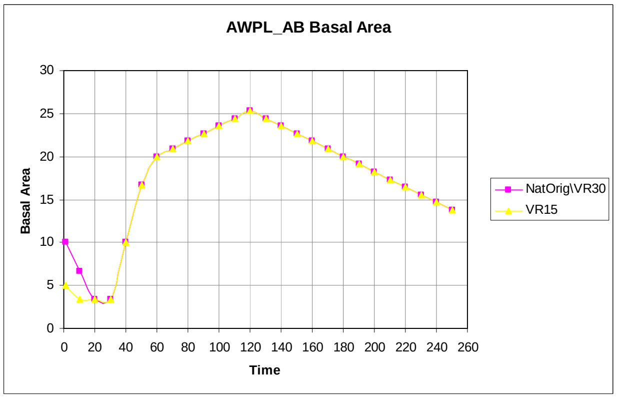
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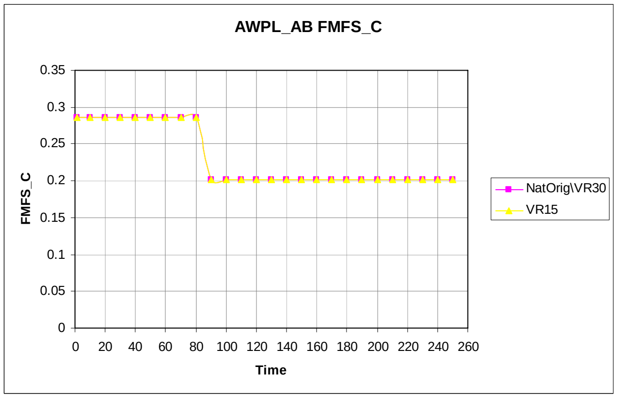
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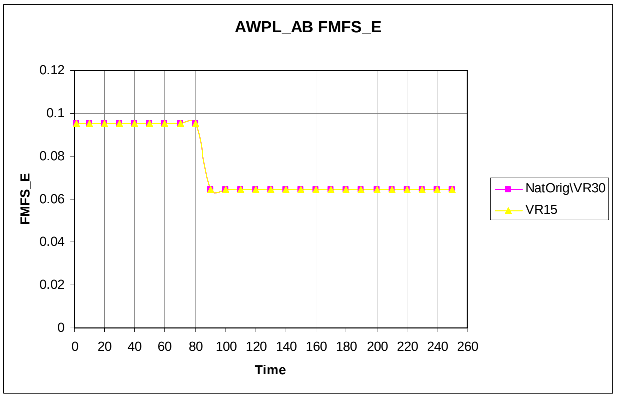
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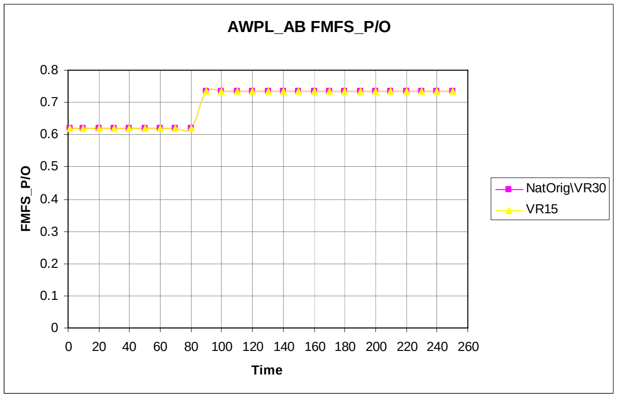
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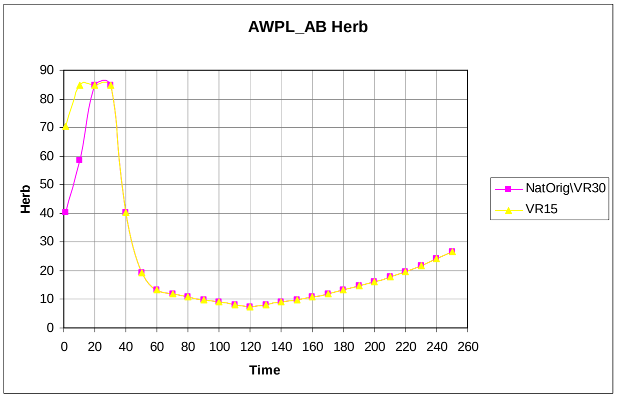
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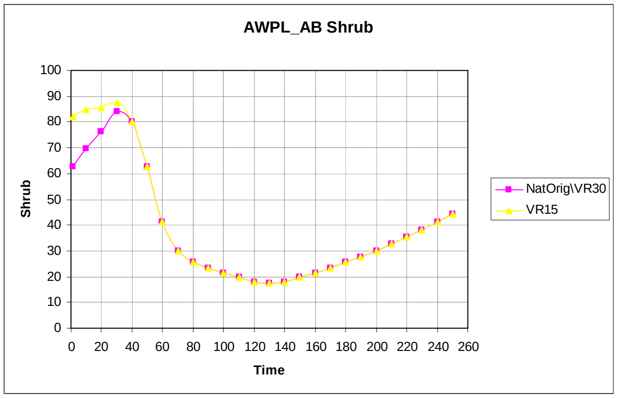
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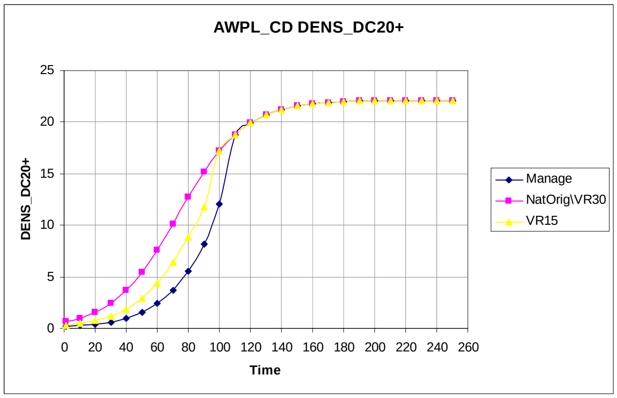
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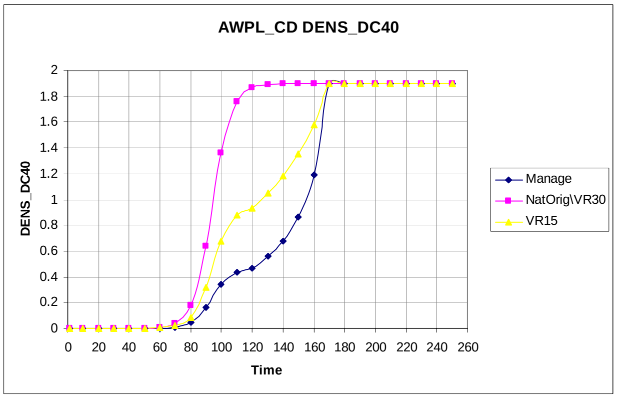
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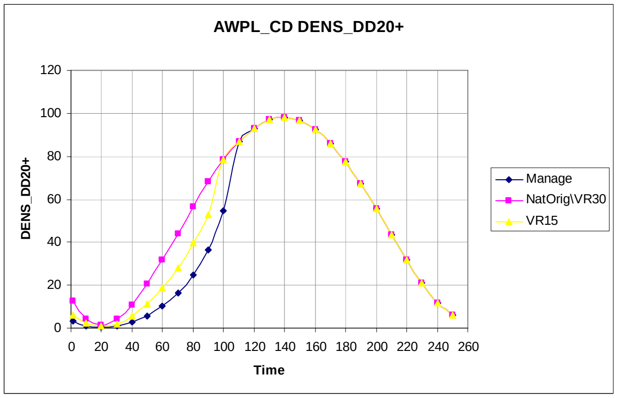
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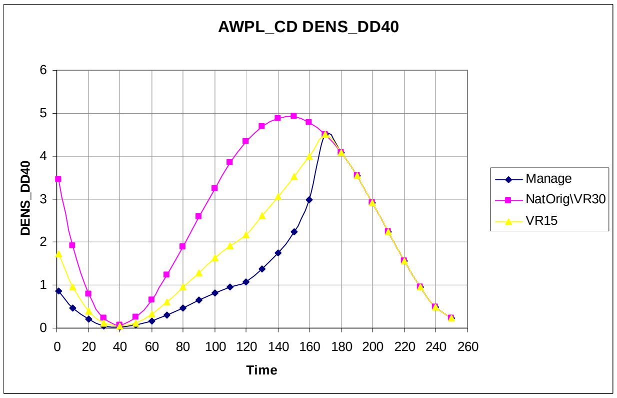
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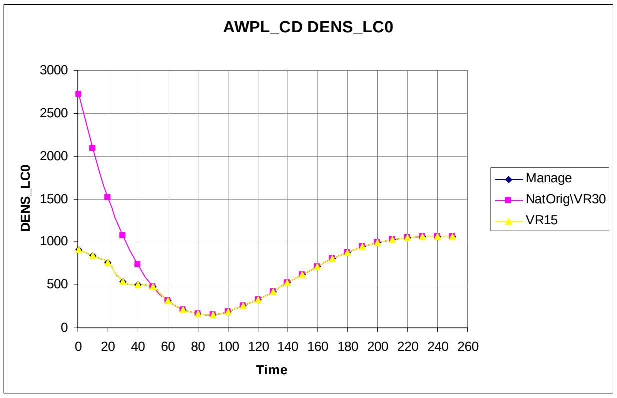
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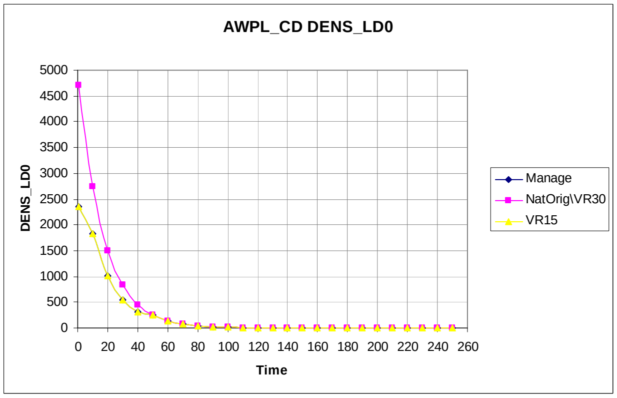
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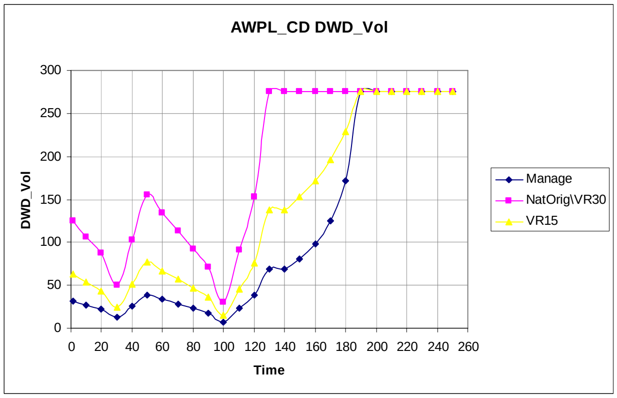
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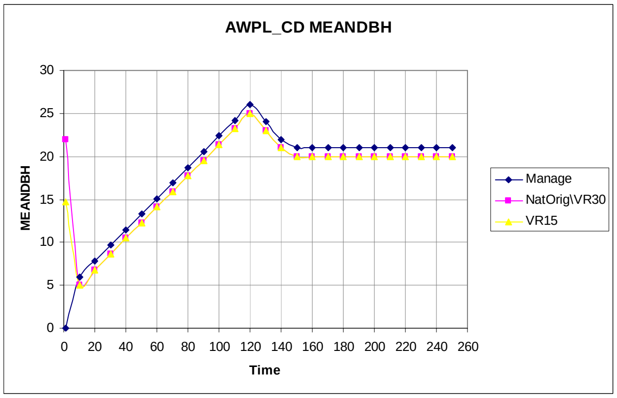
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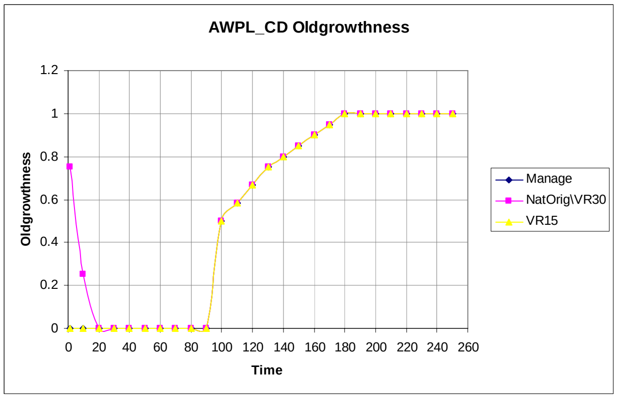
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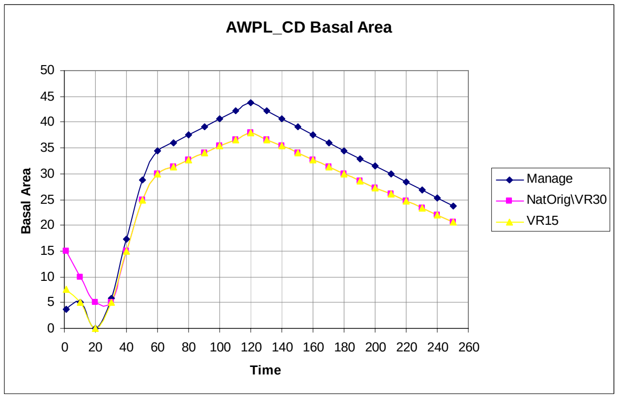
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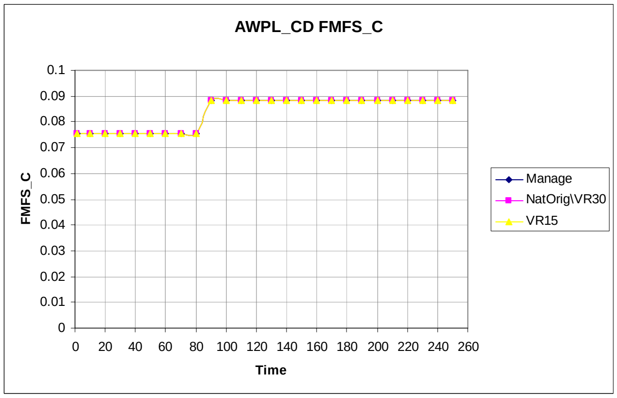
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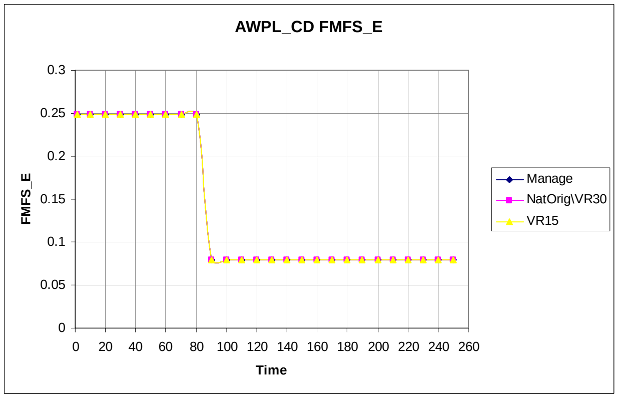
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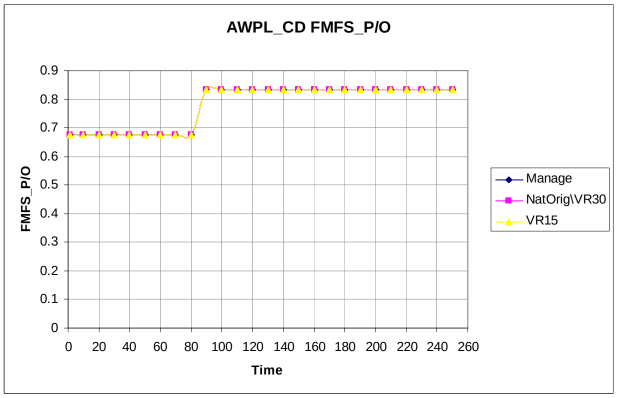
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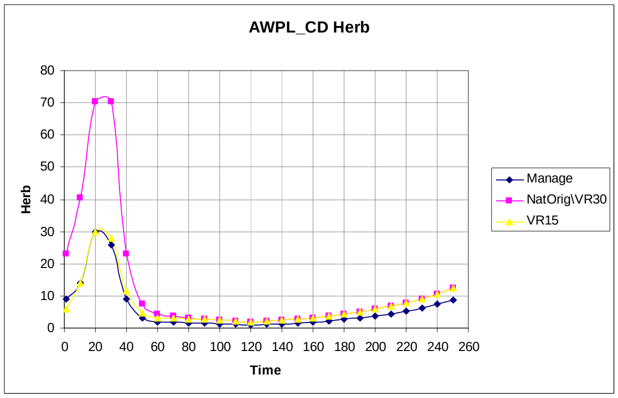
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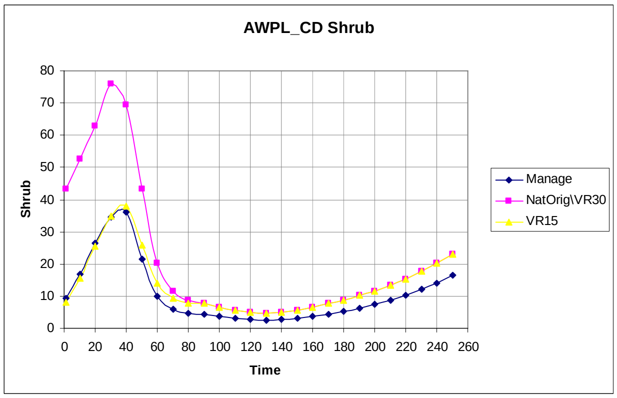
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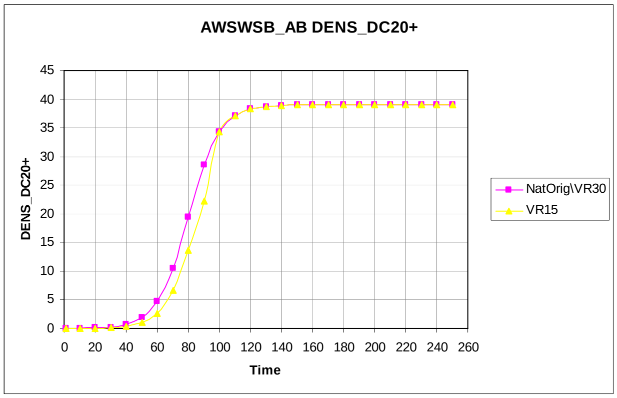
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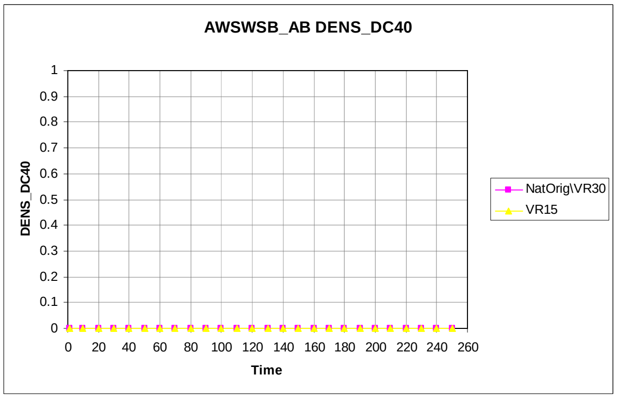
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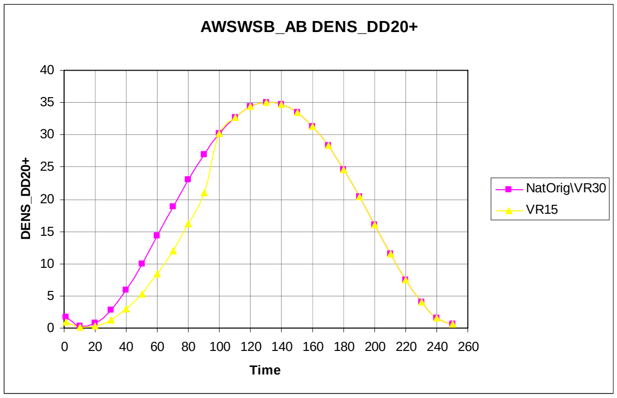
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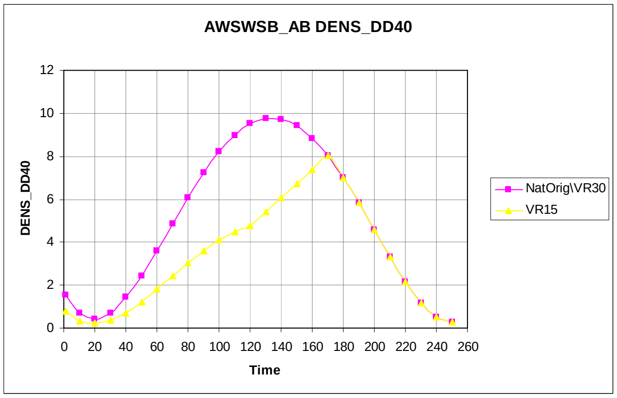
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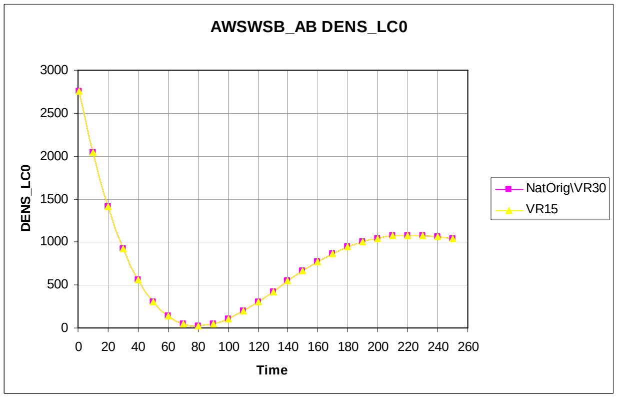
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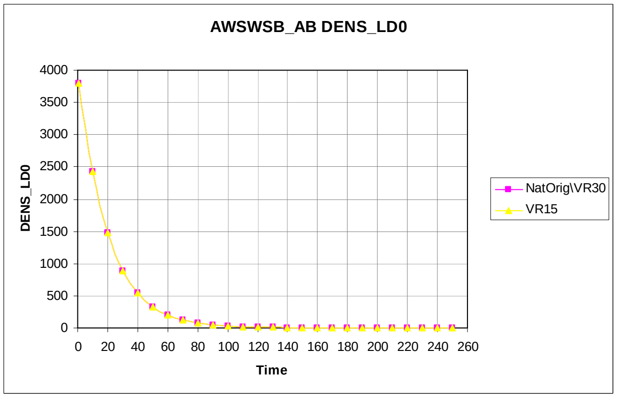
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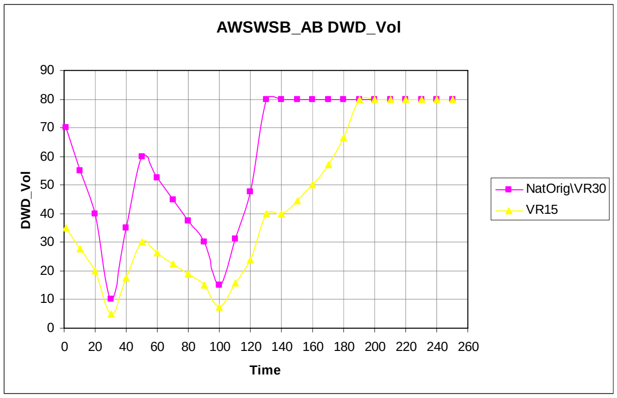
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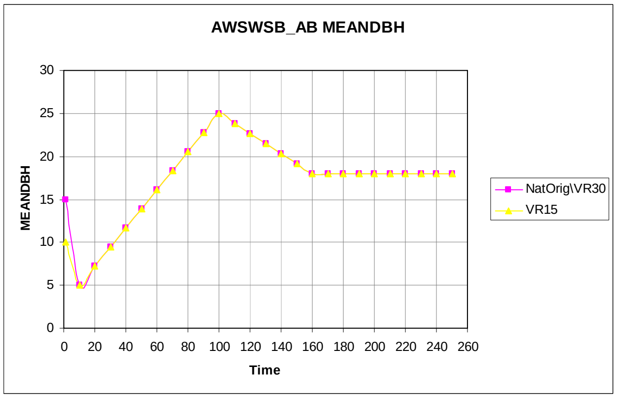
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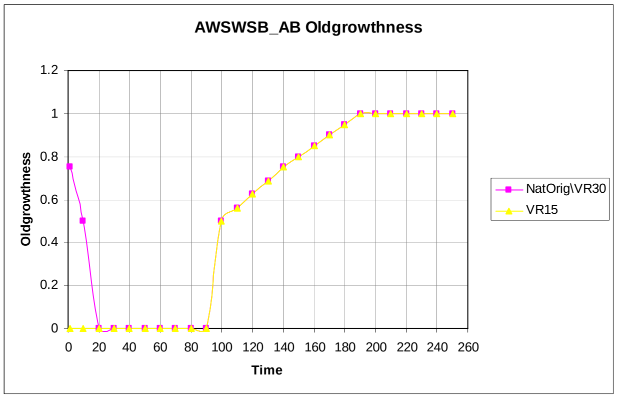
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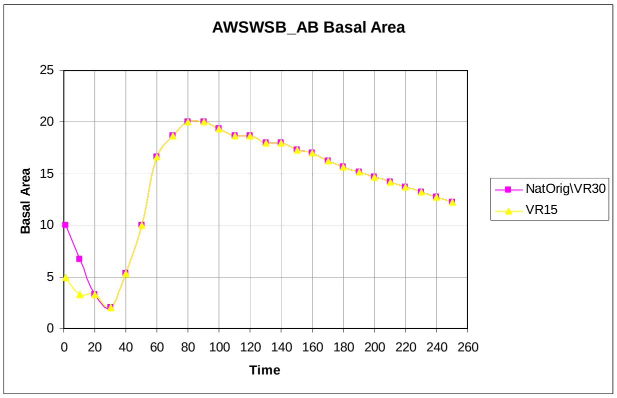
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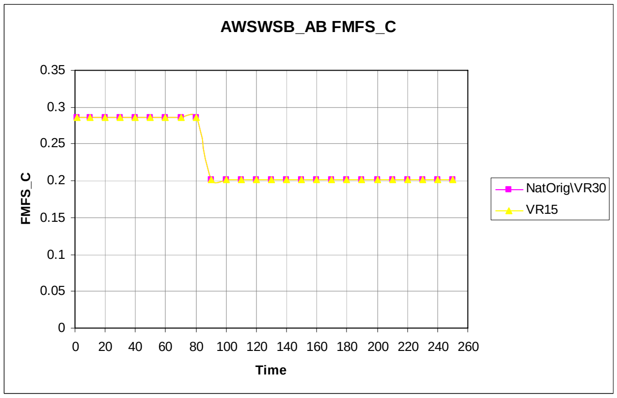
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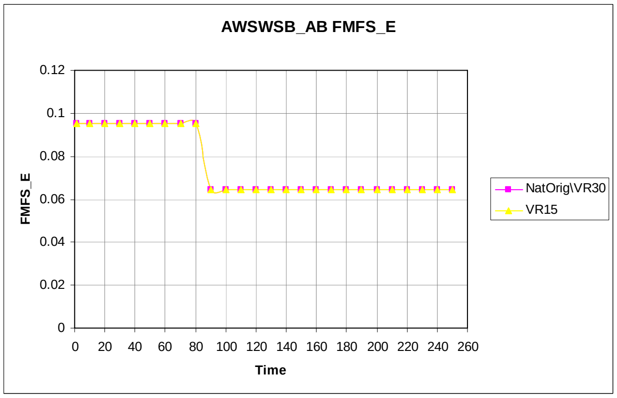
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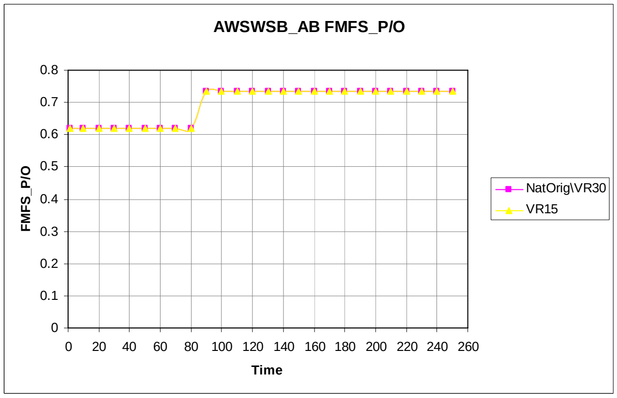
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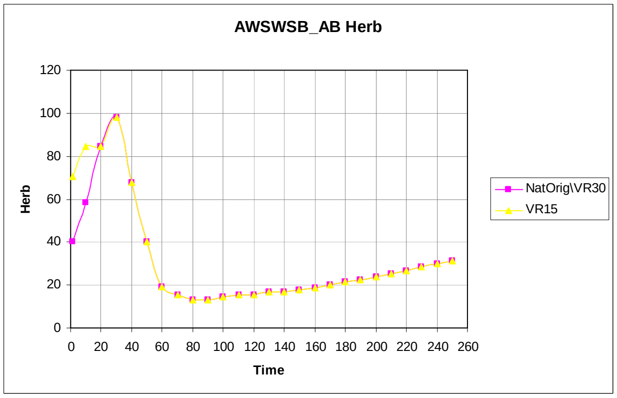
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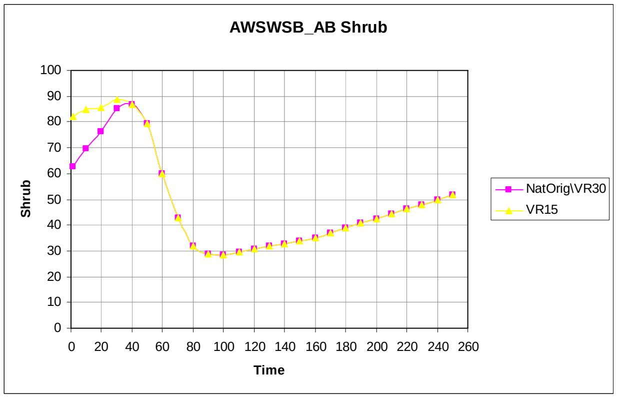
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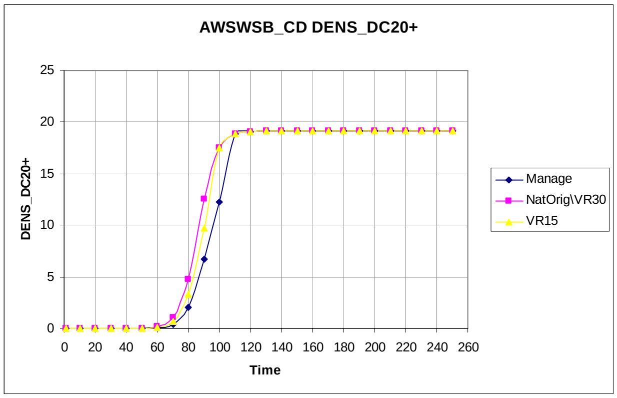
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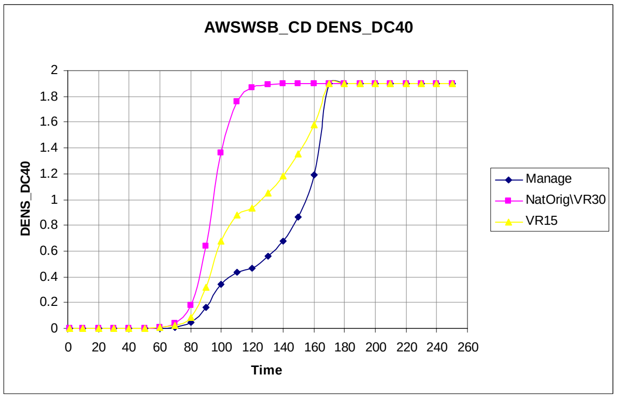
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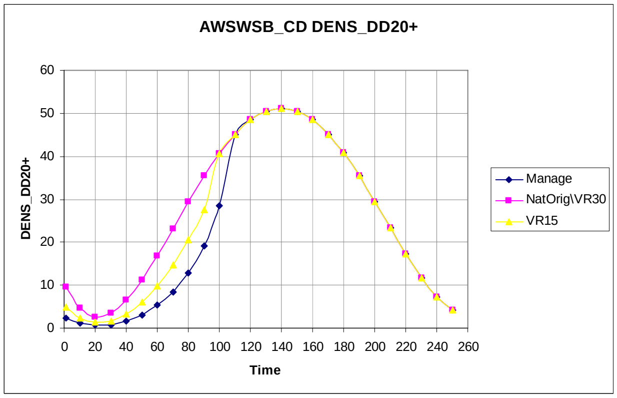
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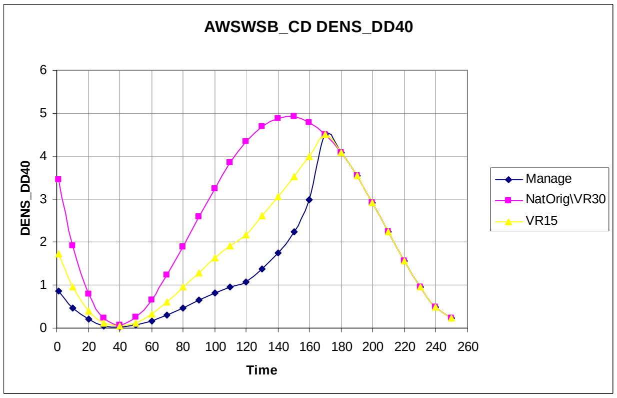
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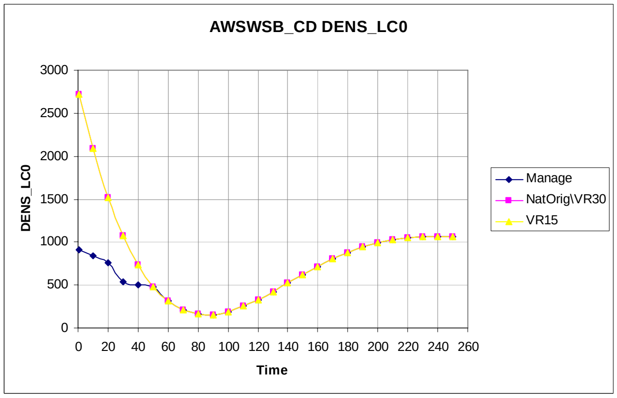
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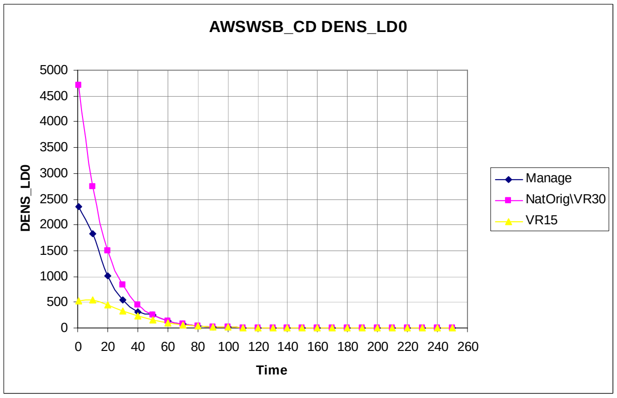
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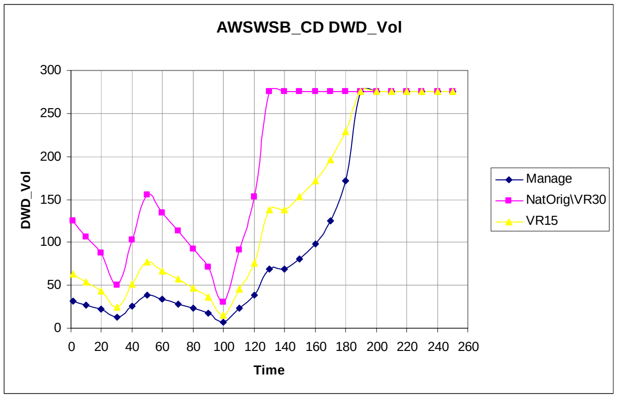
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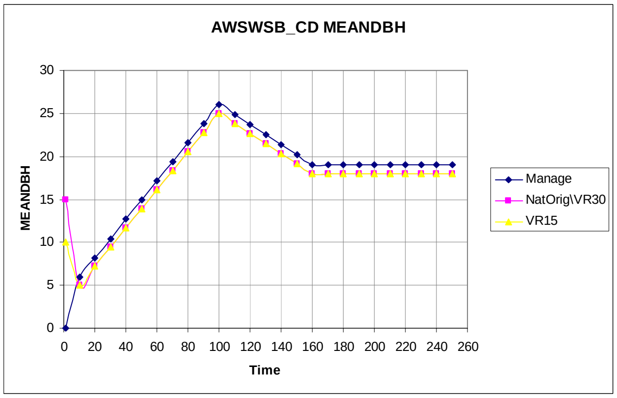
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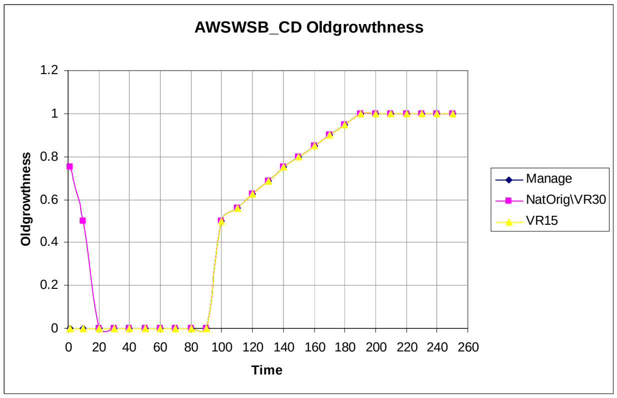
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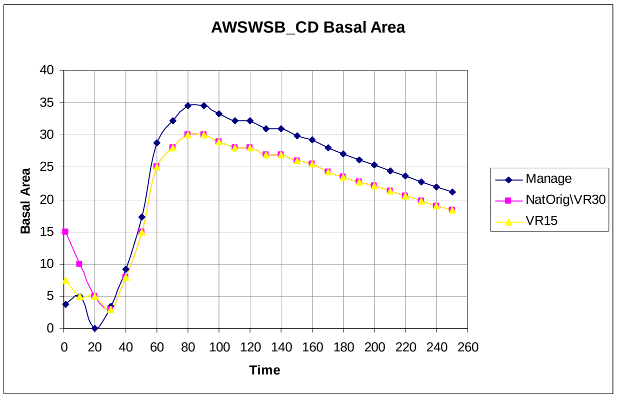
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Basal Area
Time
Manage
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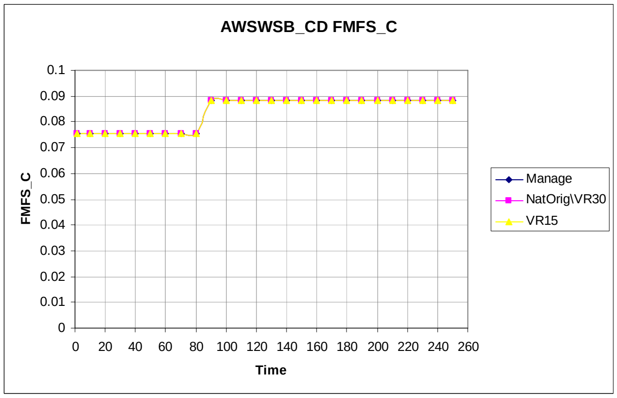
VR15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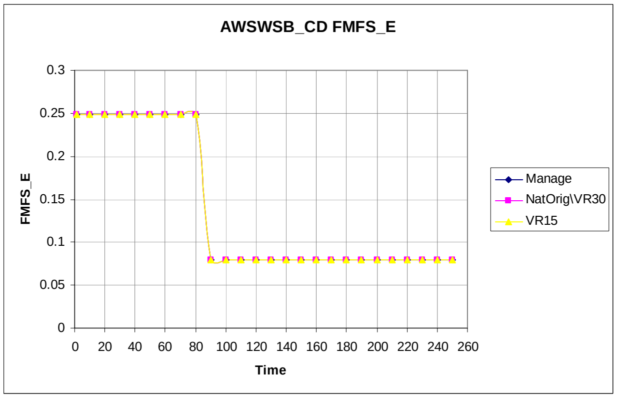
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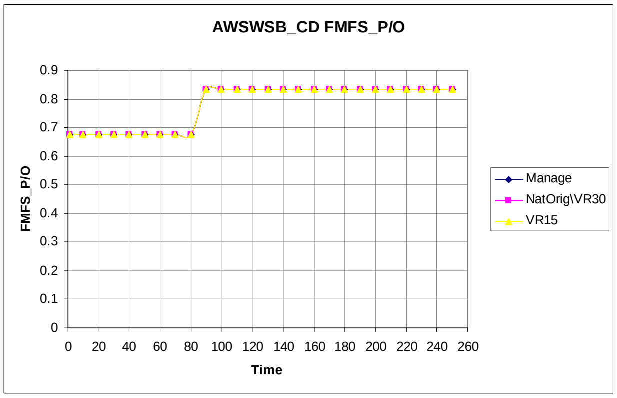
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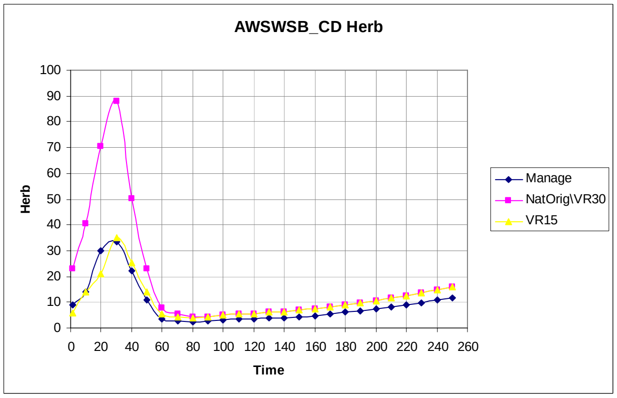
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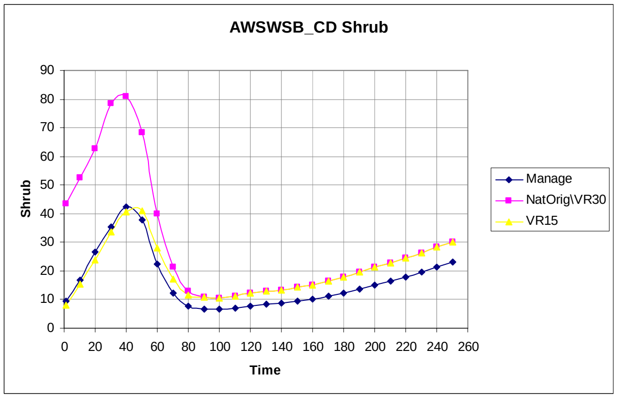
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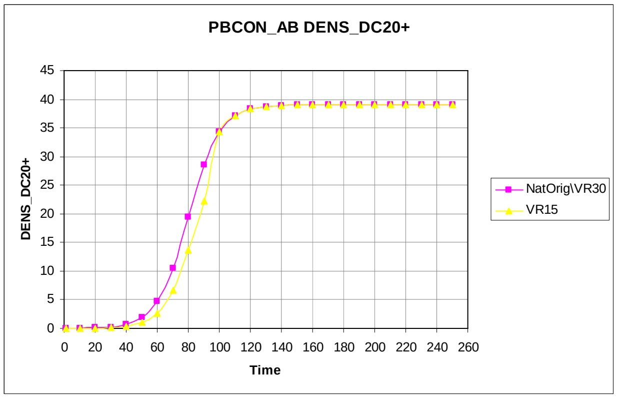
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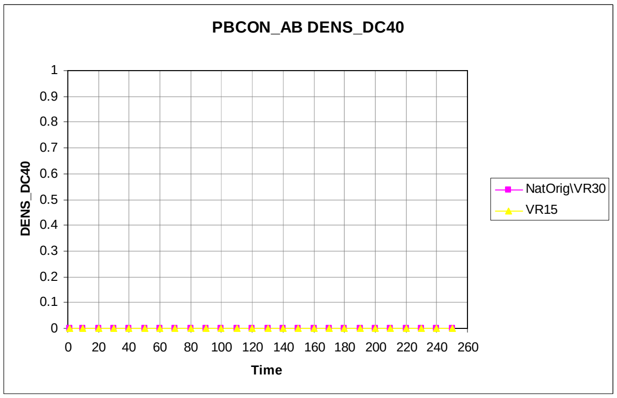
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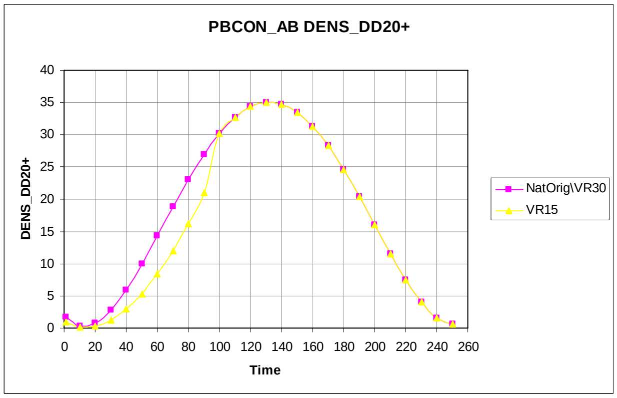
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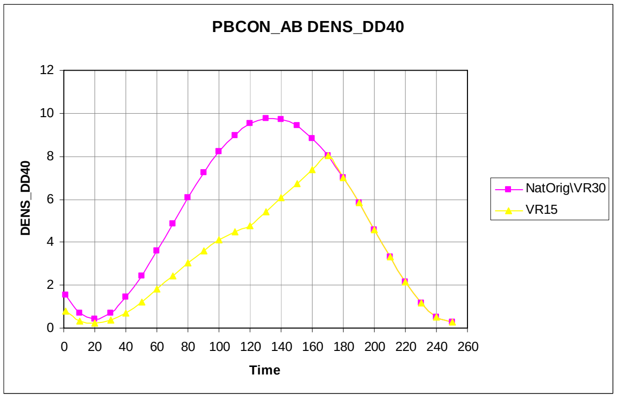
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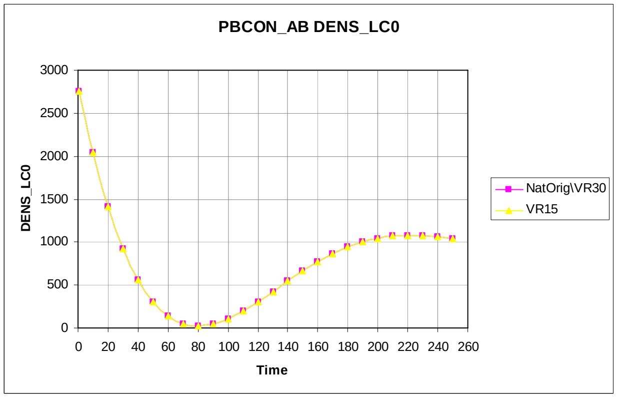
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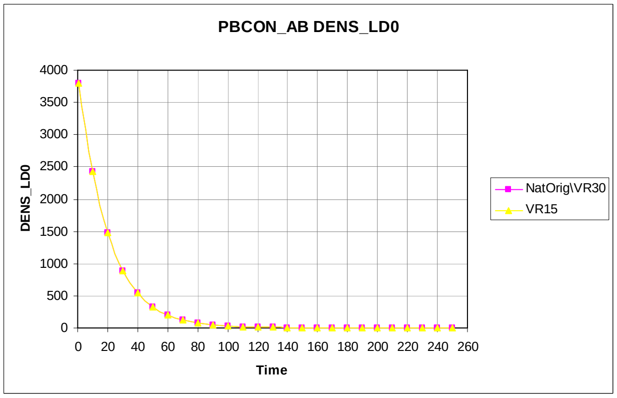
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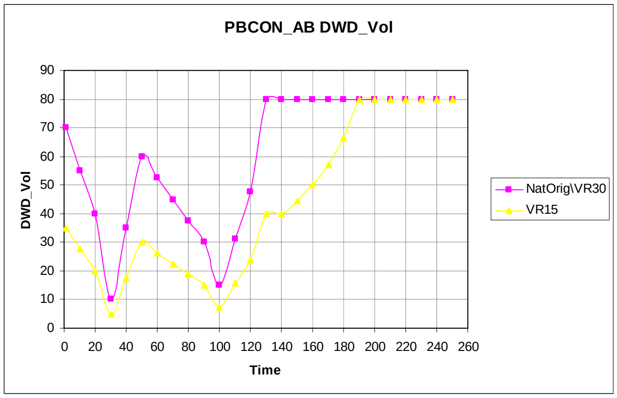
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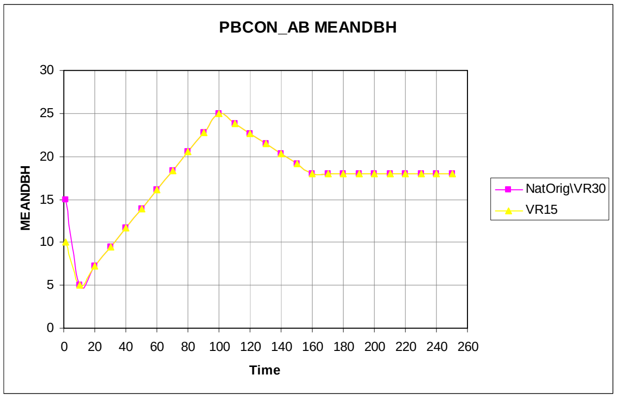
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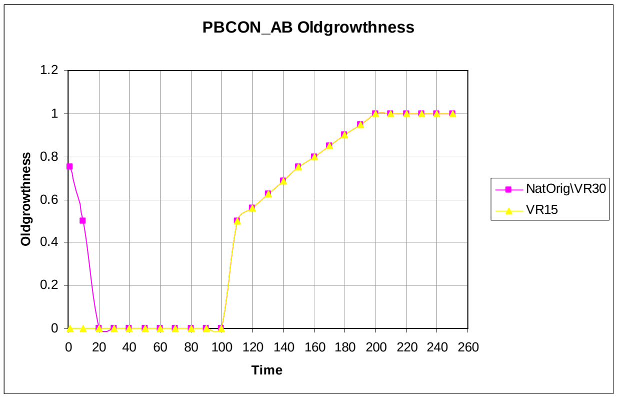
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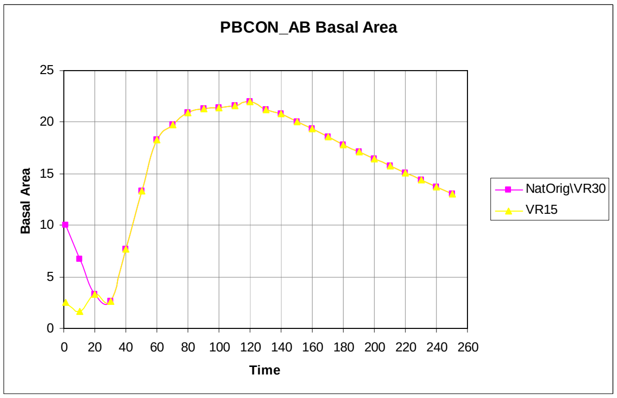
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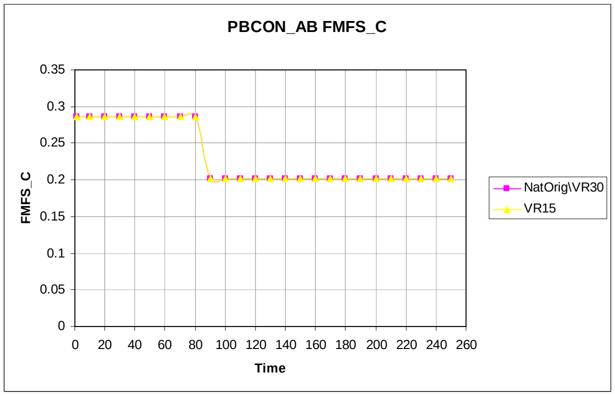
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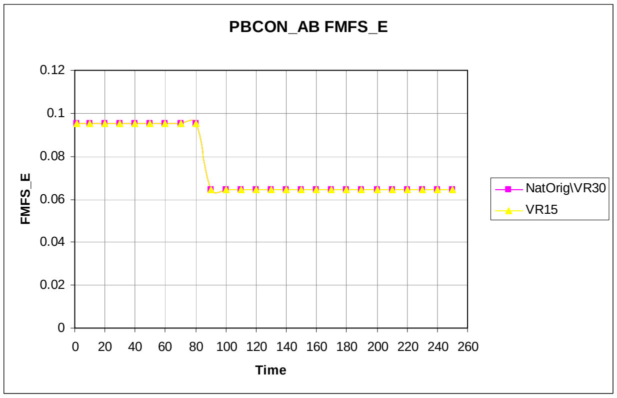
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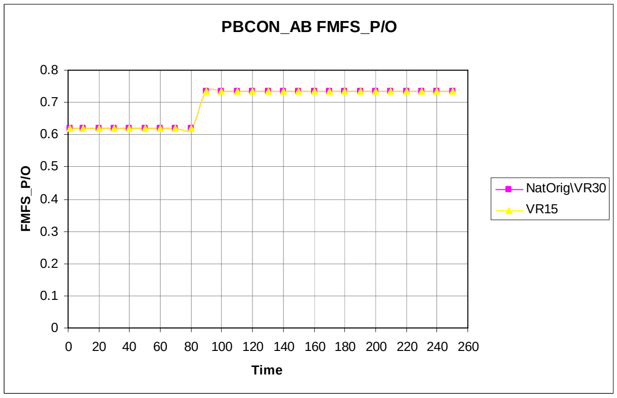
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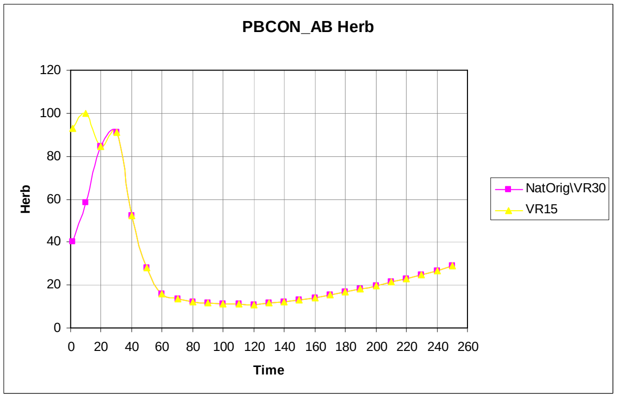
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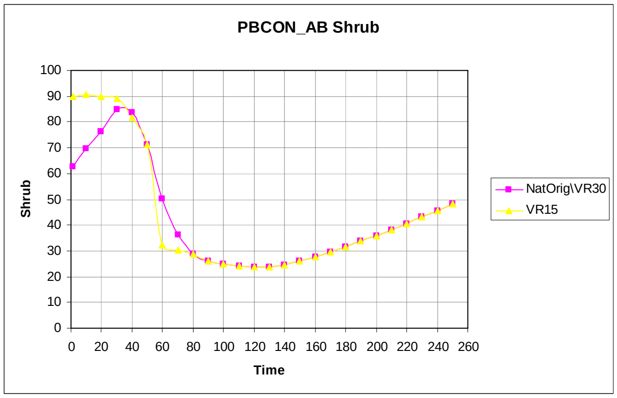
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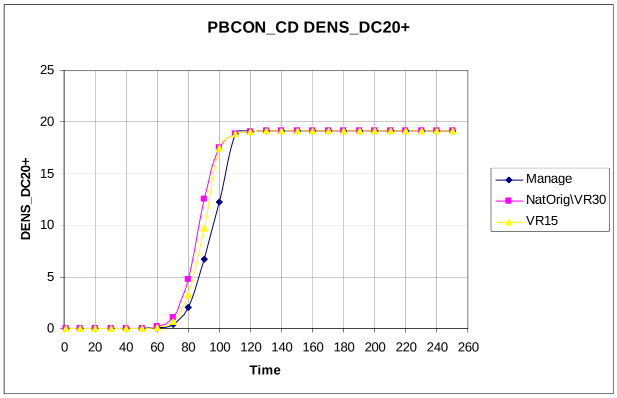
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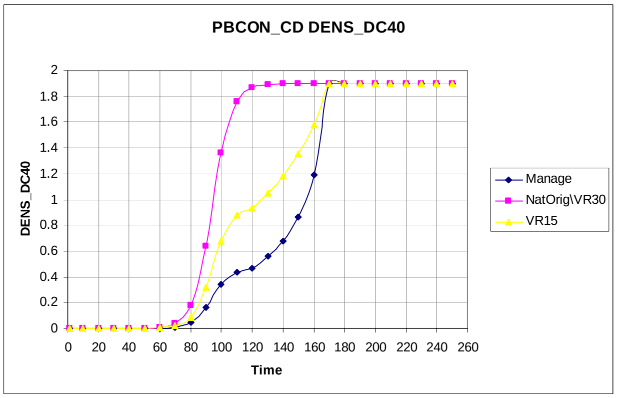
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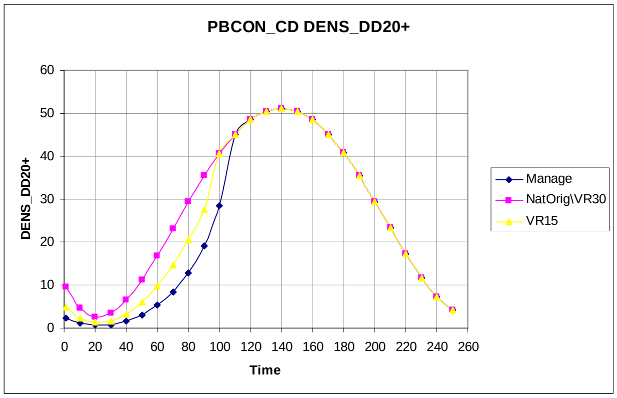
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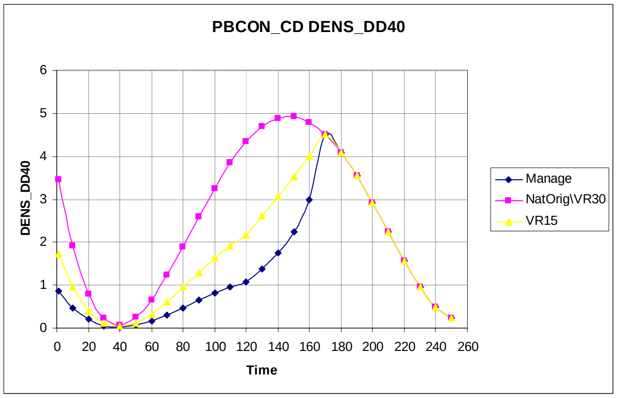
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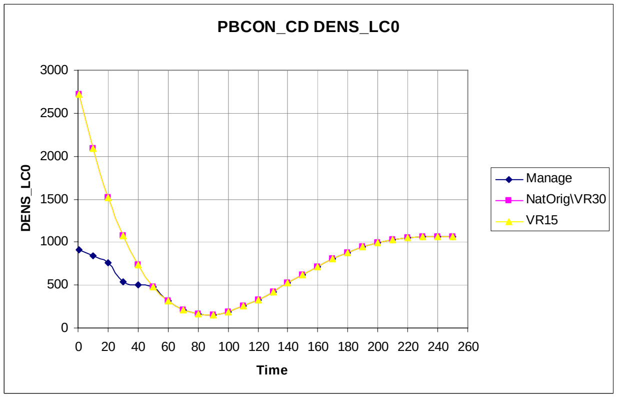
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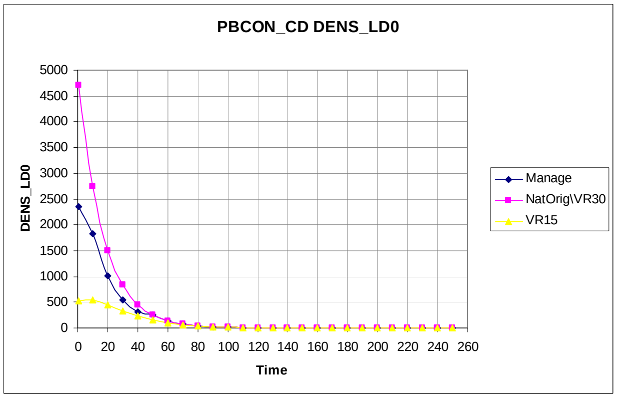
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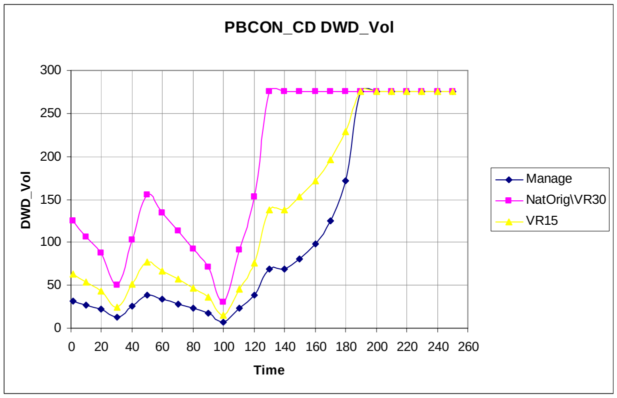
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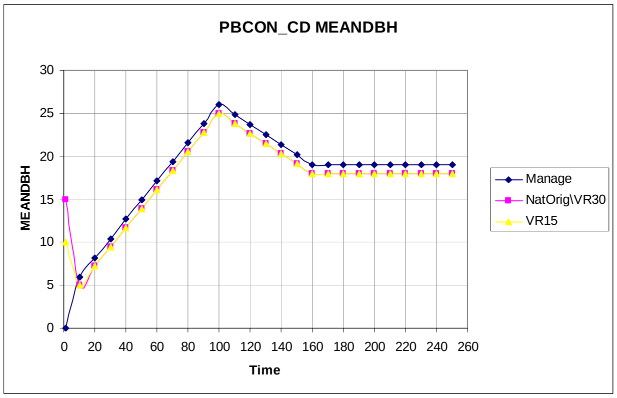
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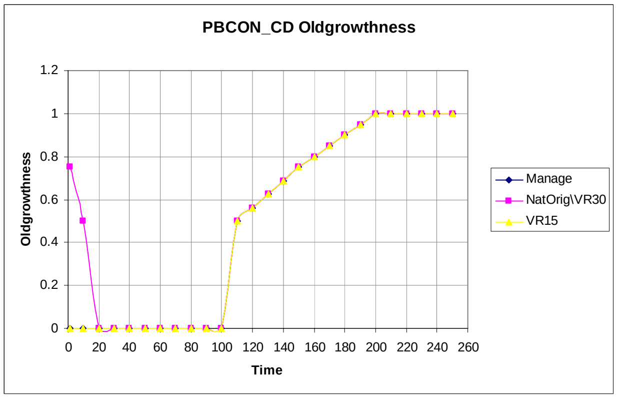
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Oldgrowthness
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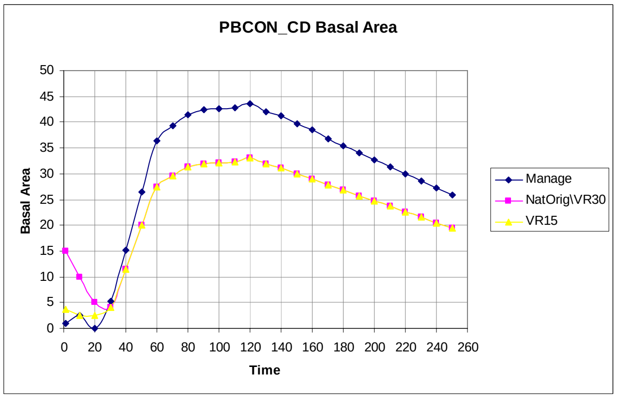
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Basal Area
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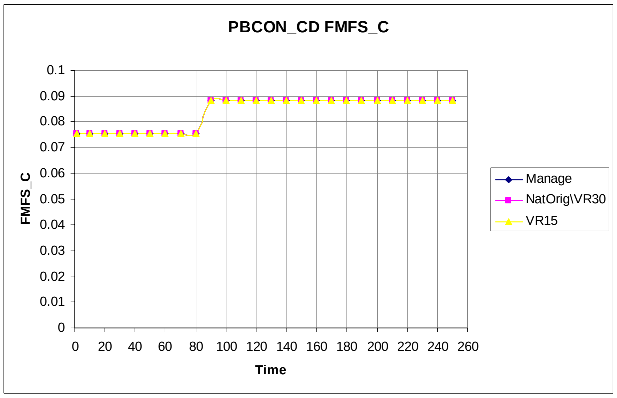
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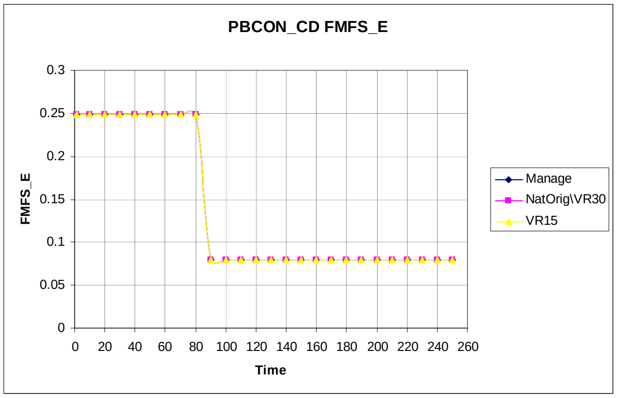
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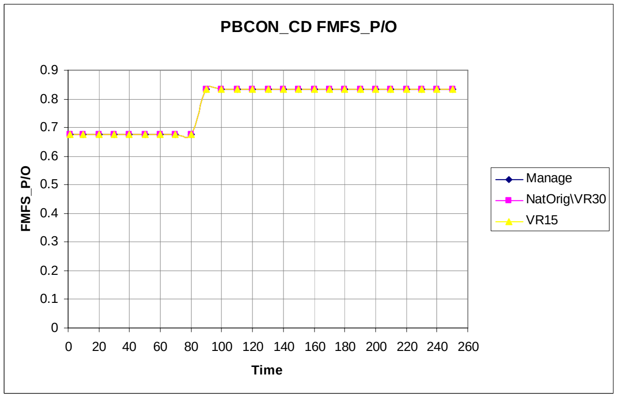
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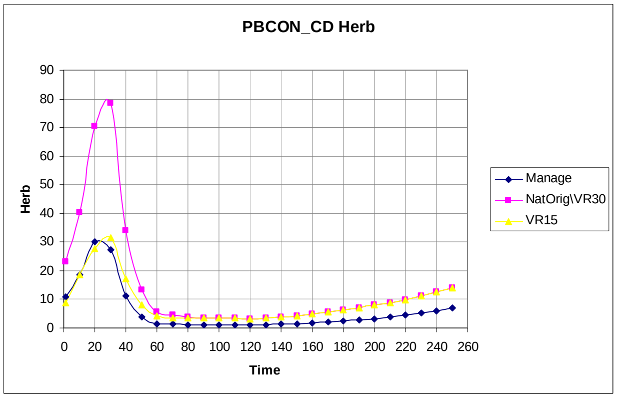
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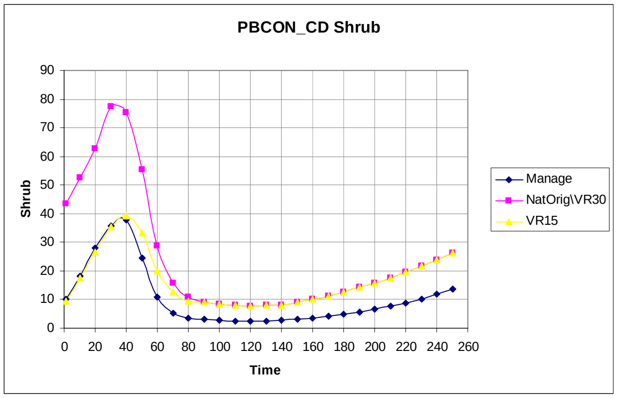
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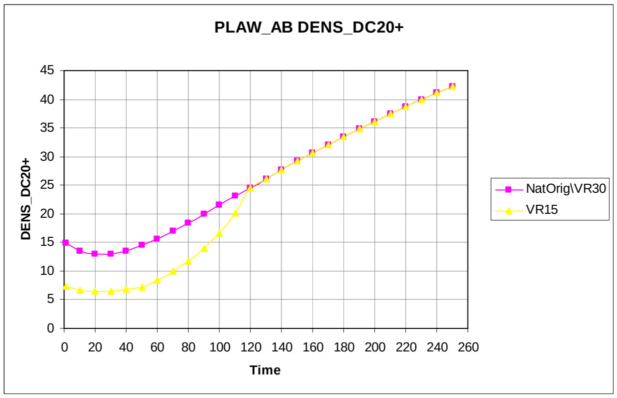
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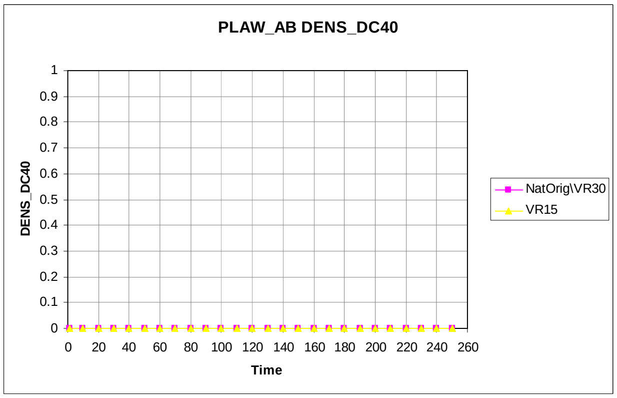
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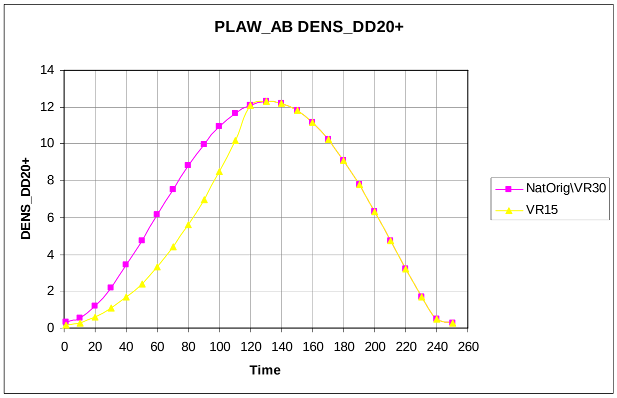
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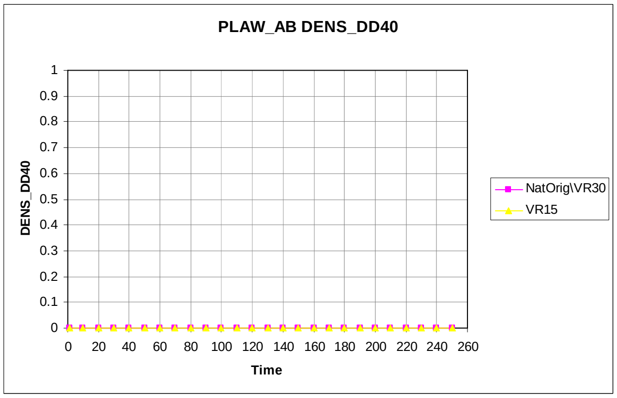
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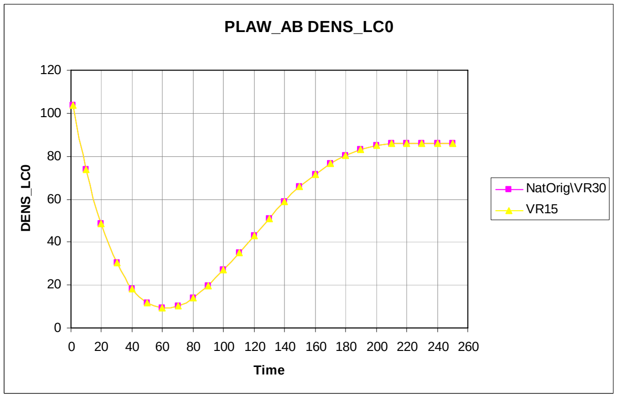
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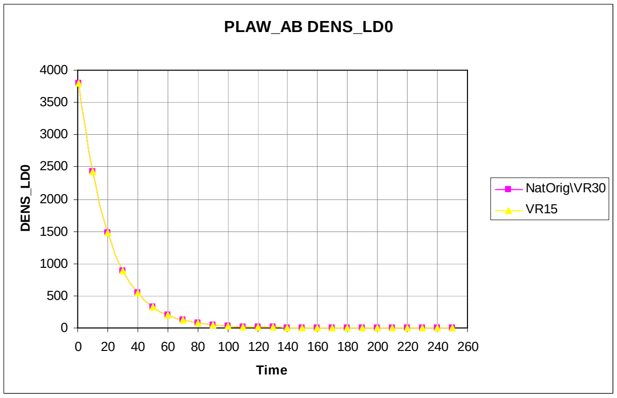
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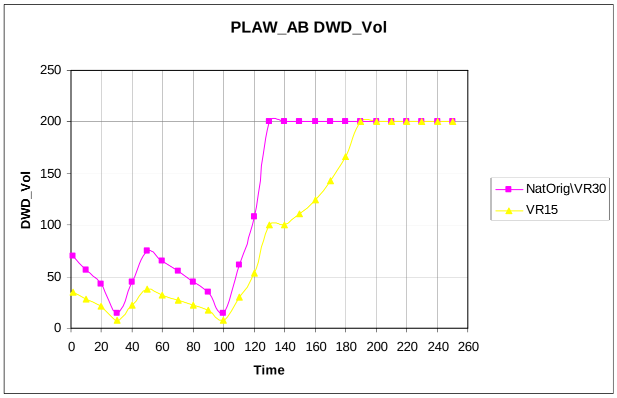
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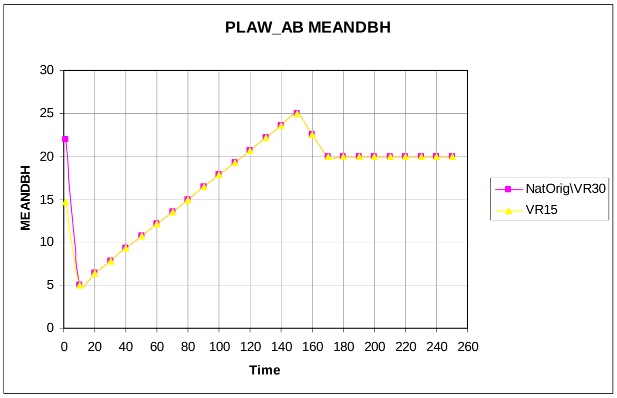
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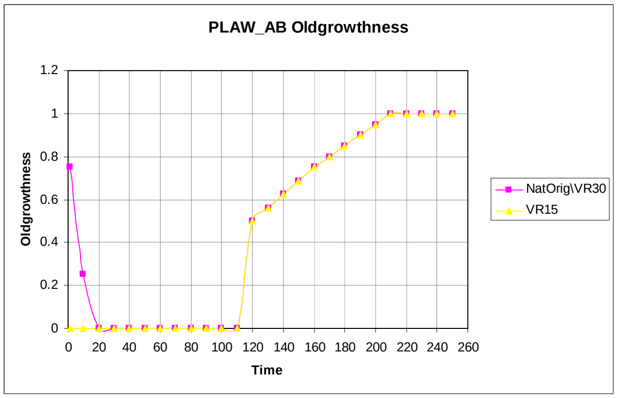
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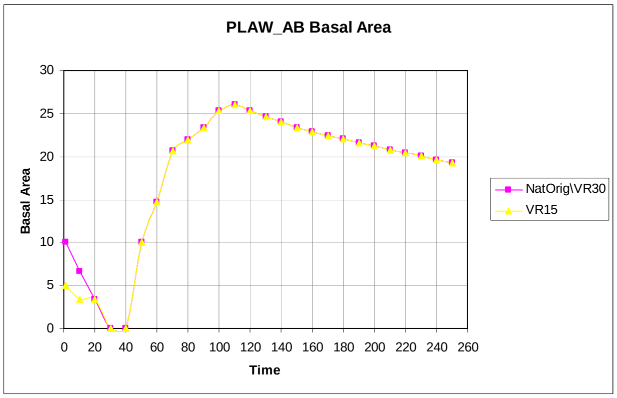
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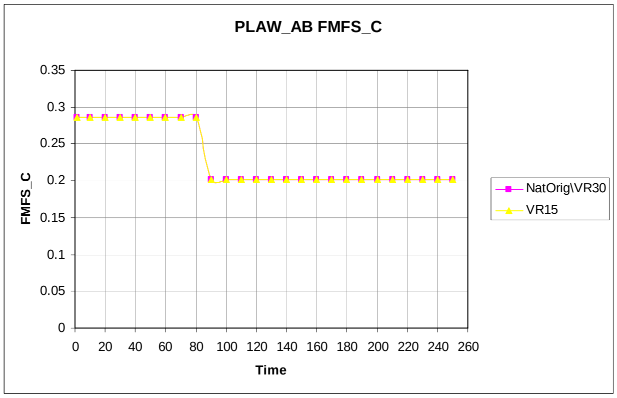
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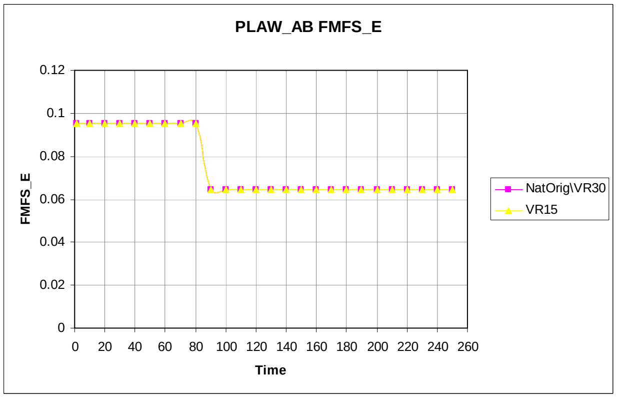
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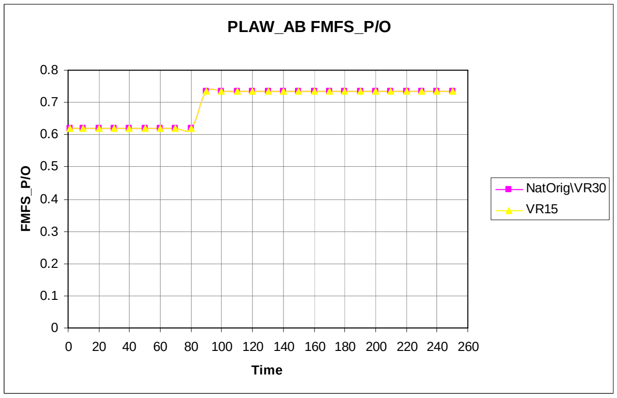
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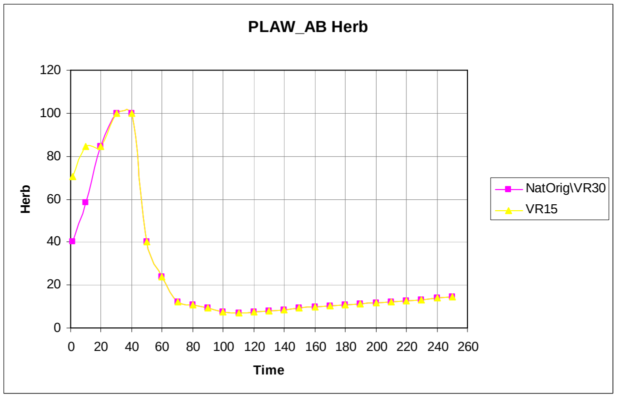
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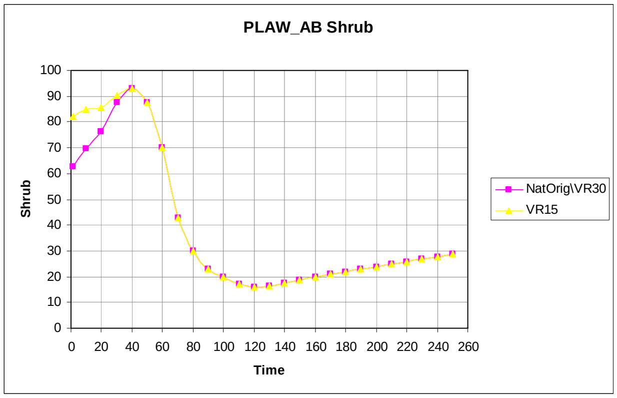
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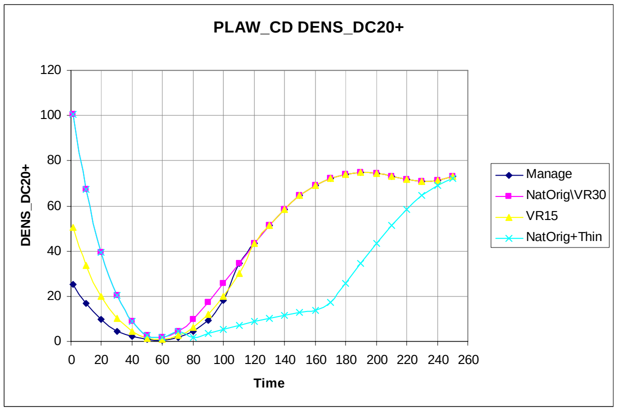
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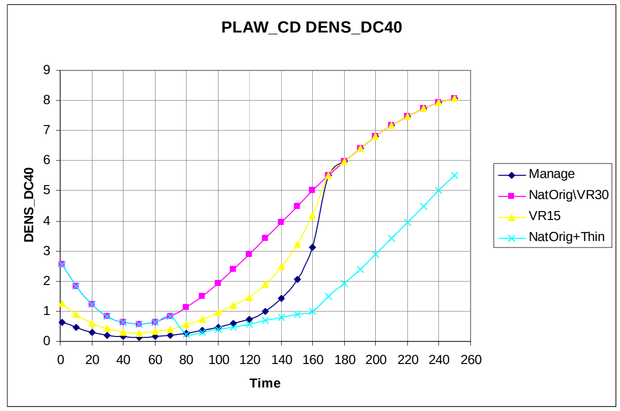
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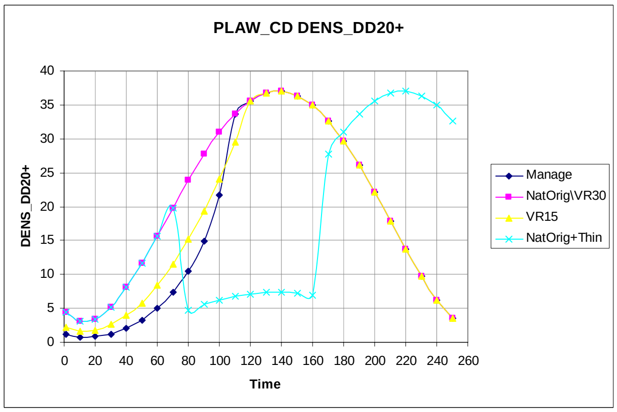
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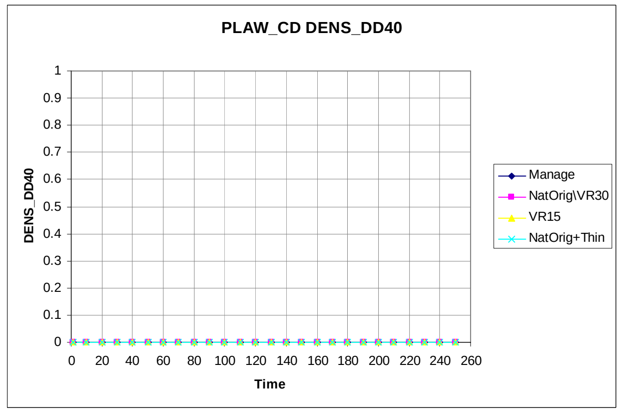
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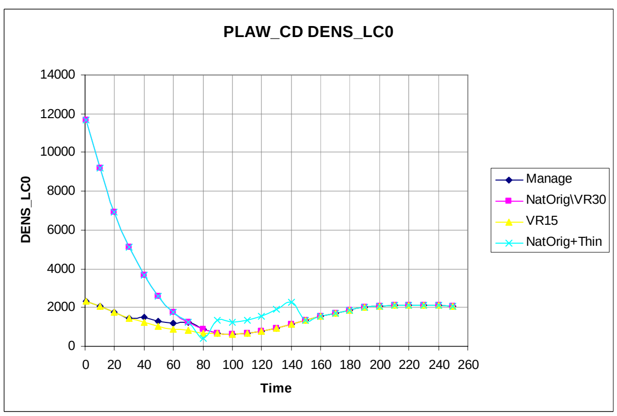
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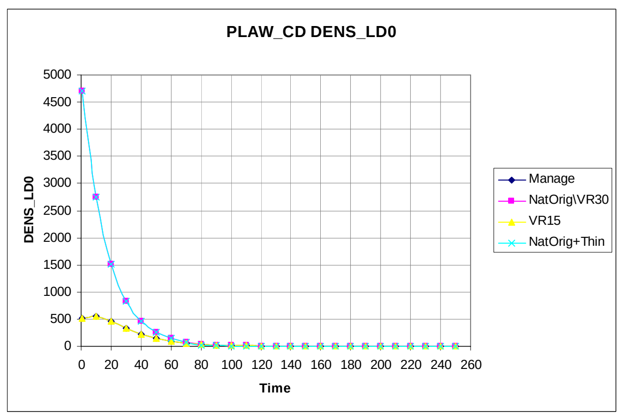
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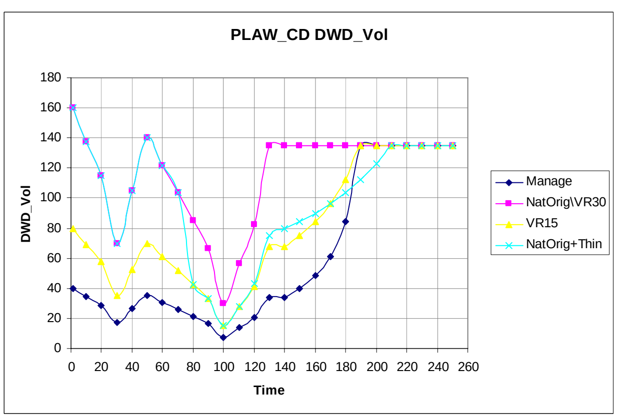
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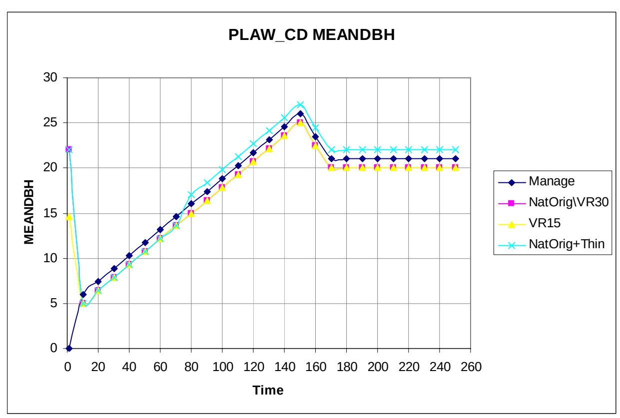
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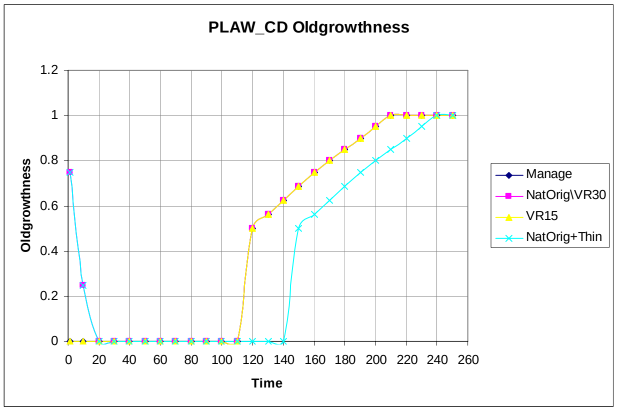
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Oldgrowthness
Time
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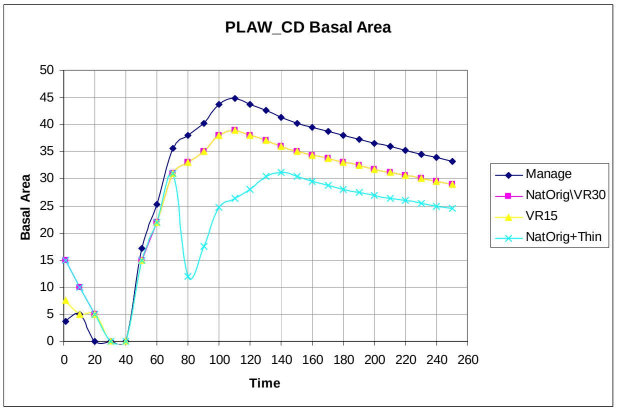
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Time
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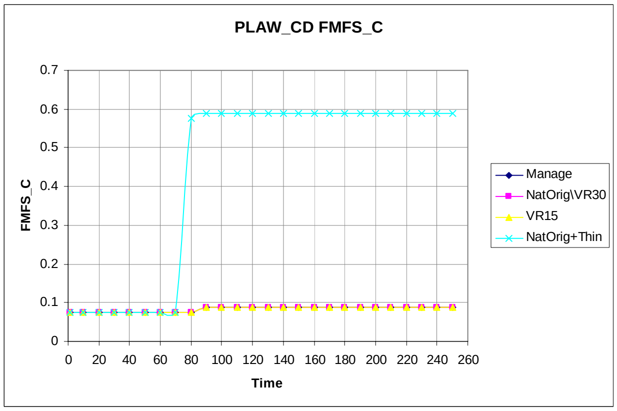
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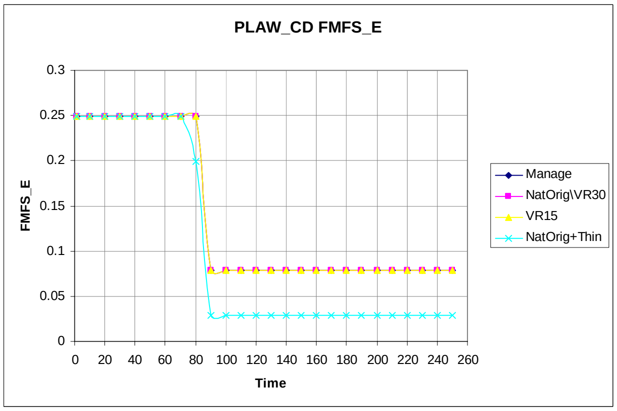
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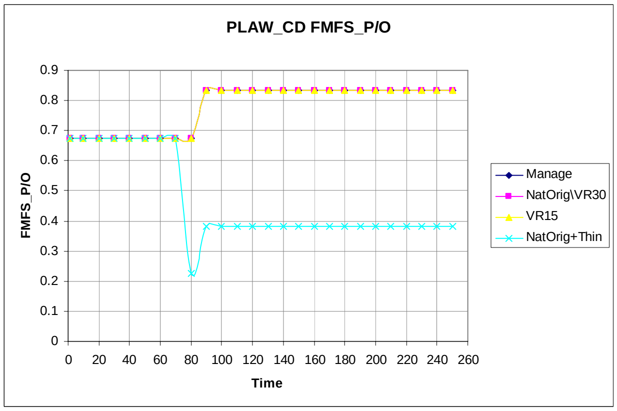
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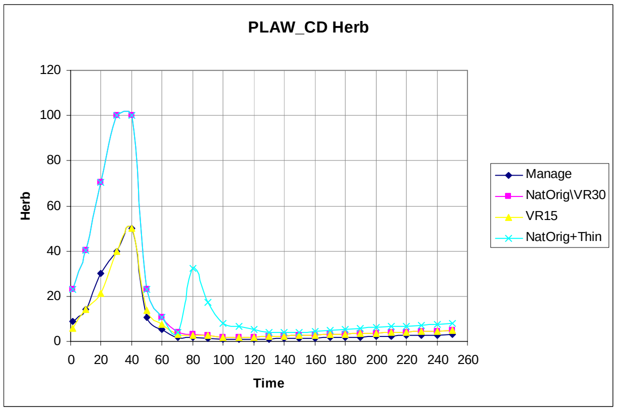
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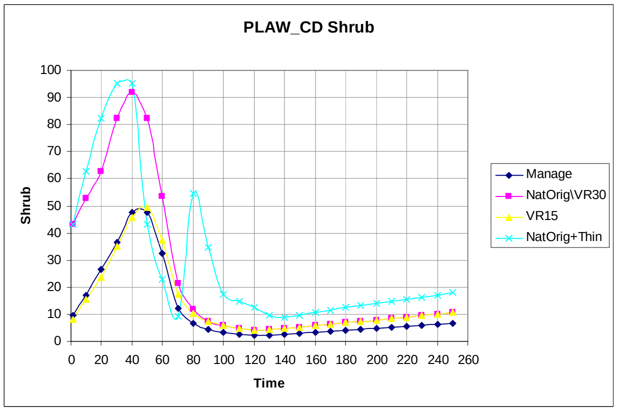
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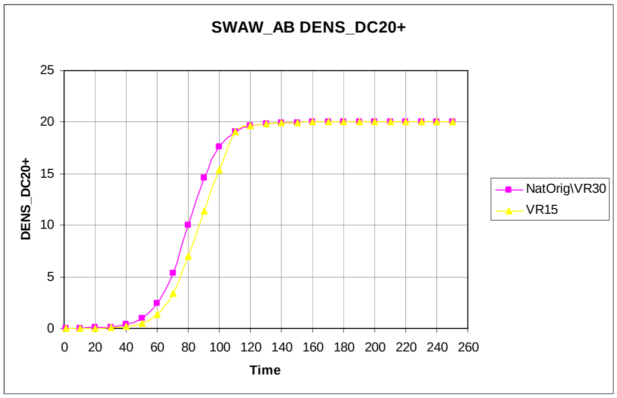
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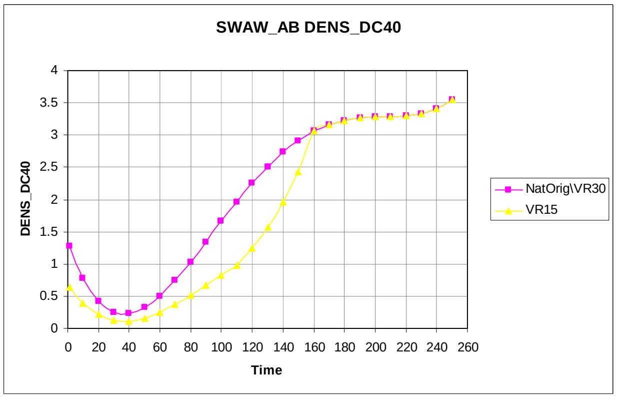
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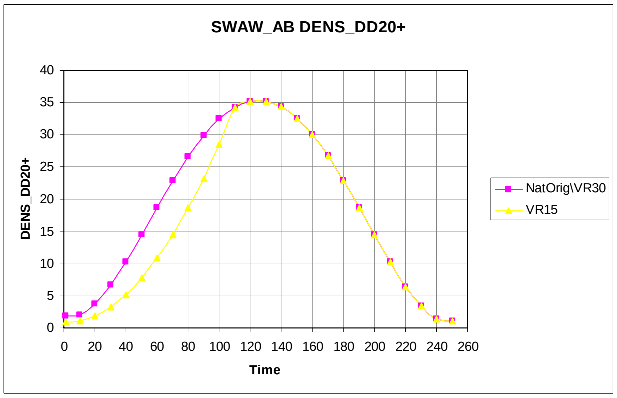
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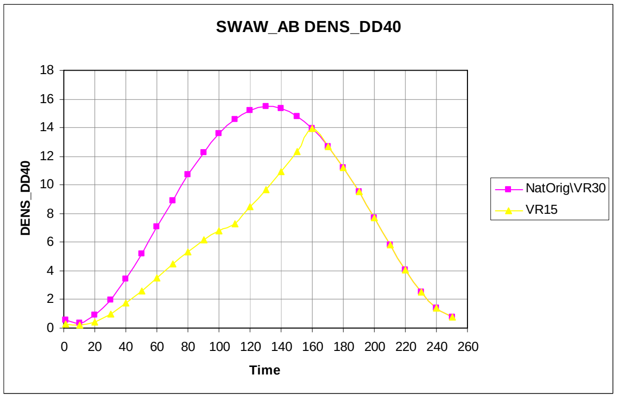
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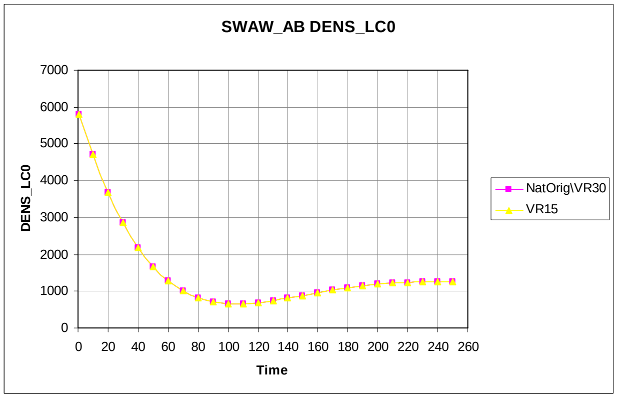
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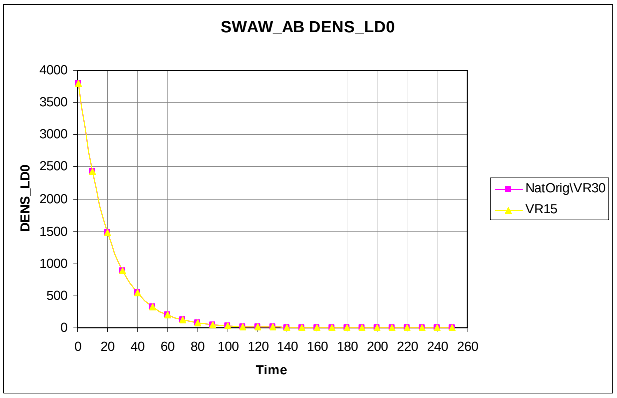
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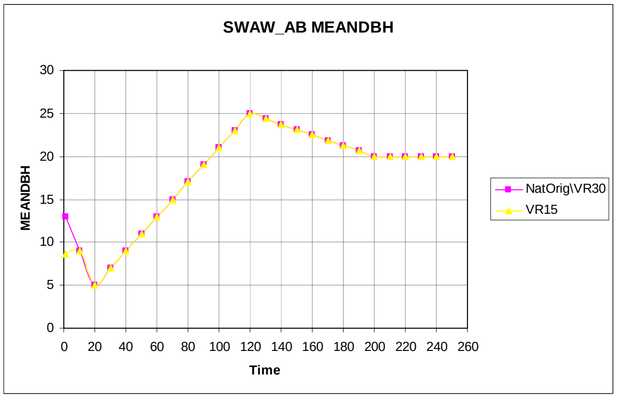
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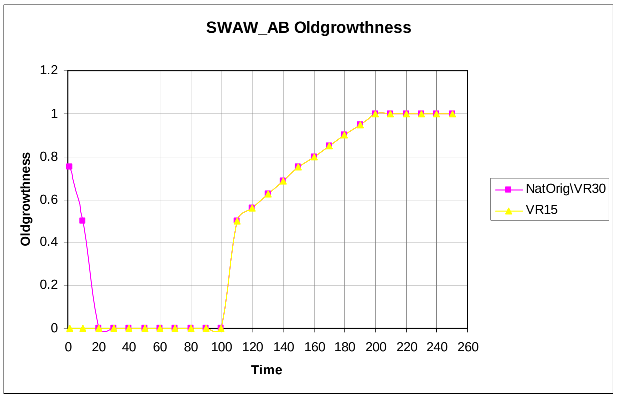
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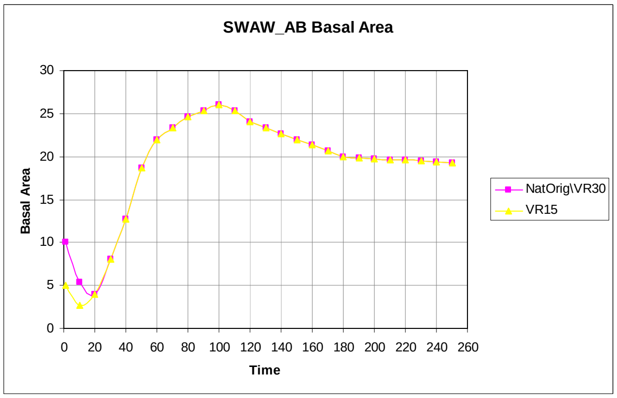
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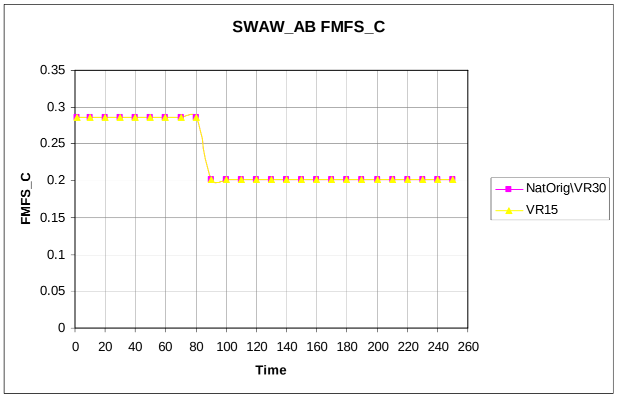
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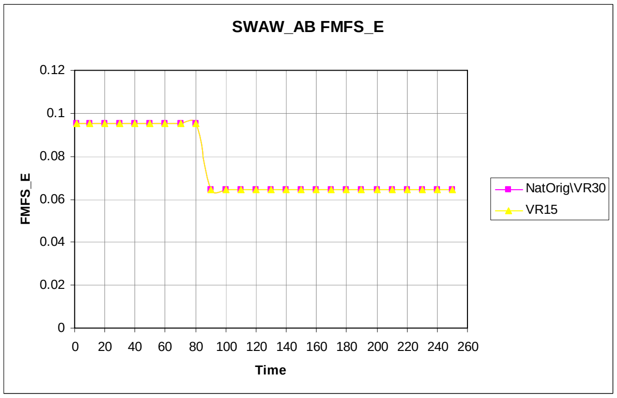
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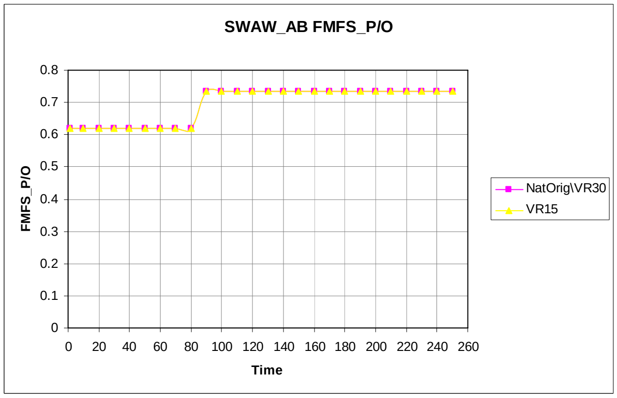
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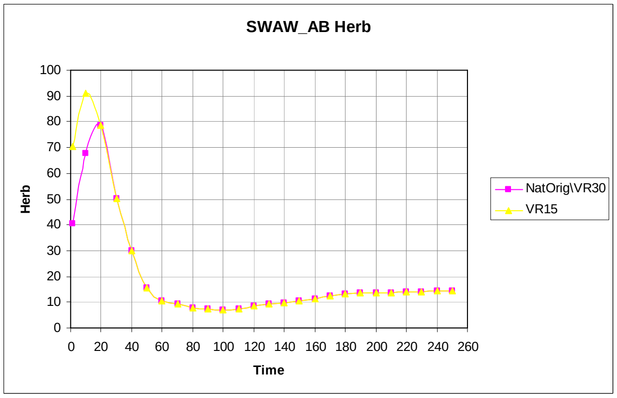
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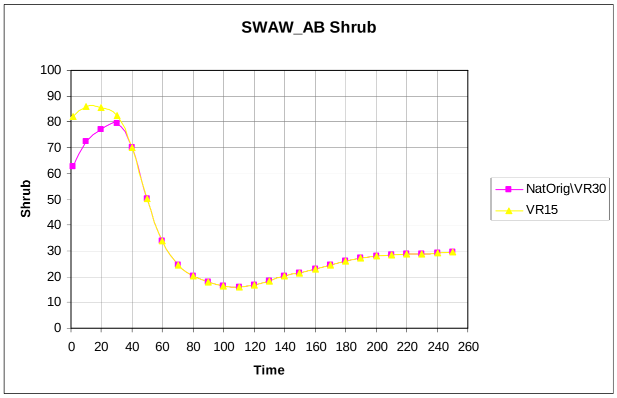
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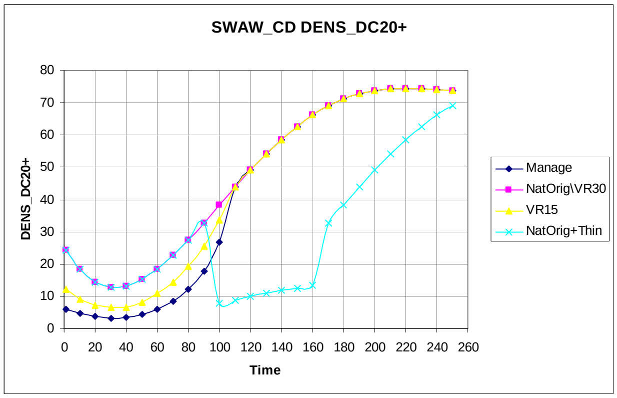
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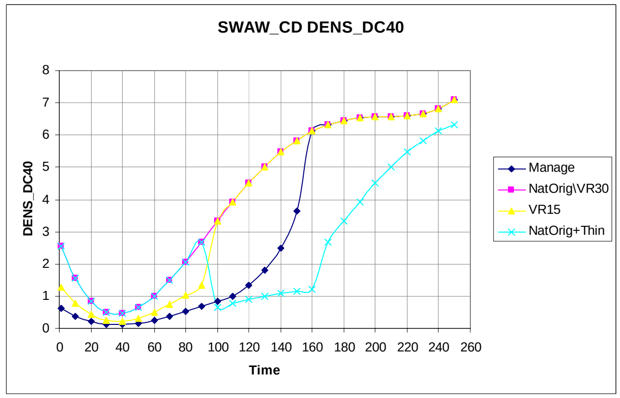
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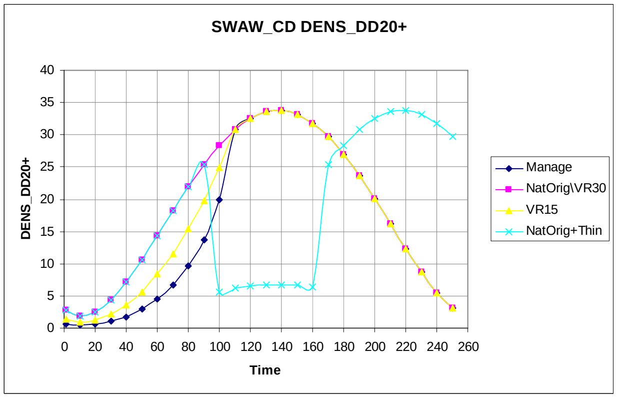
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SWAW_CD DENS_DD40
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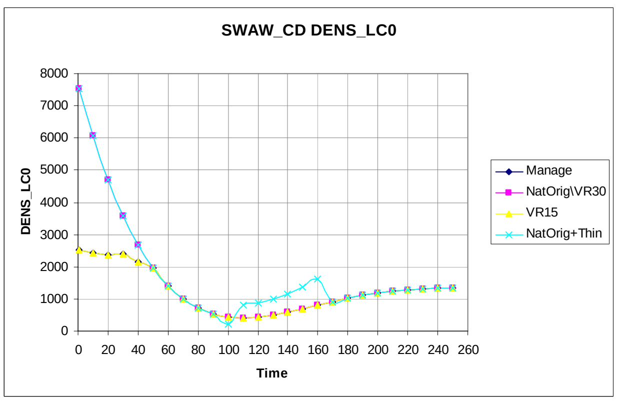
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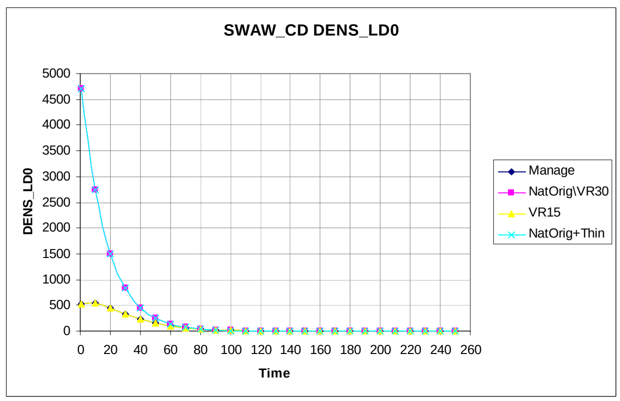
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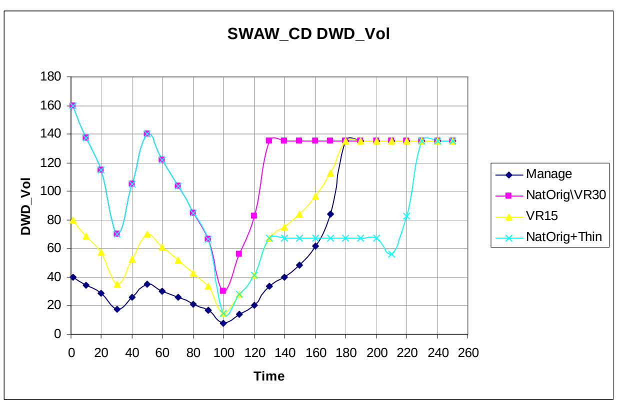
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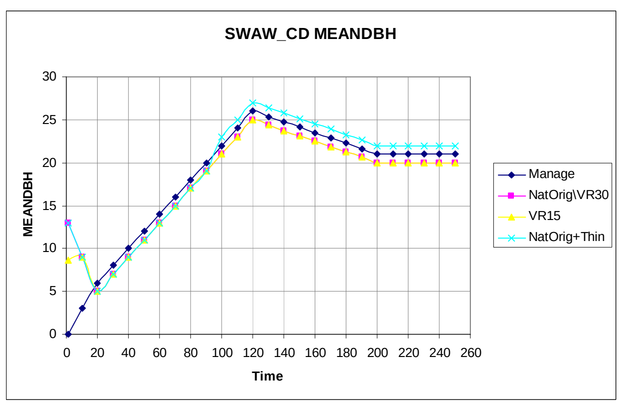
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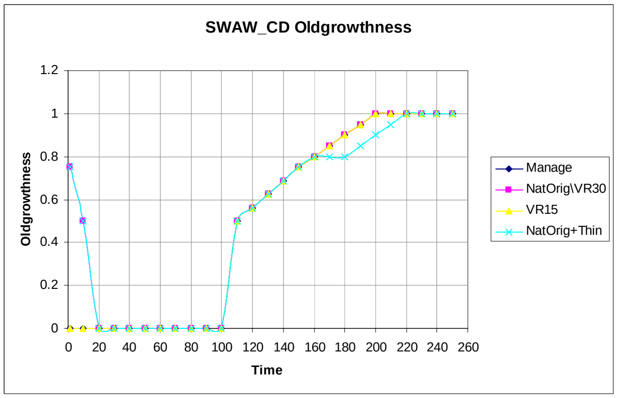
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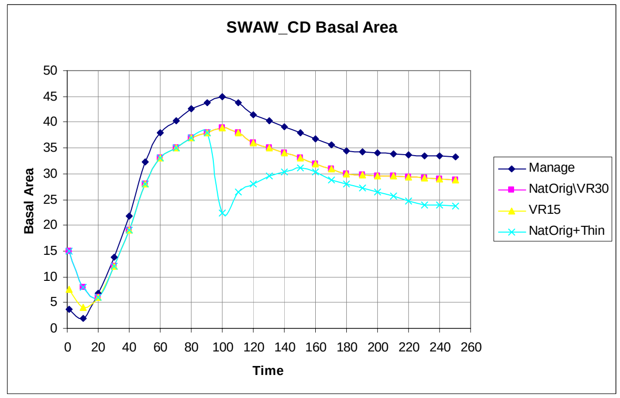
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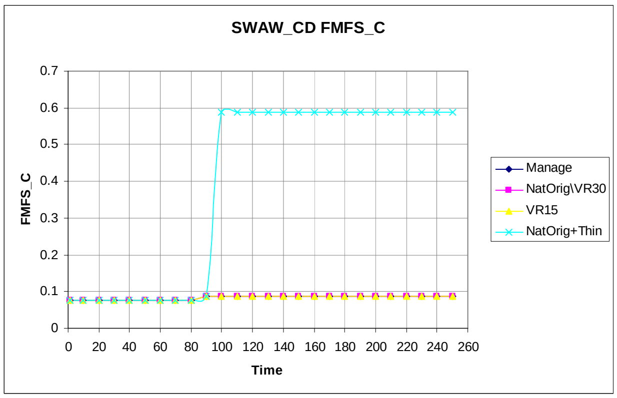
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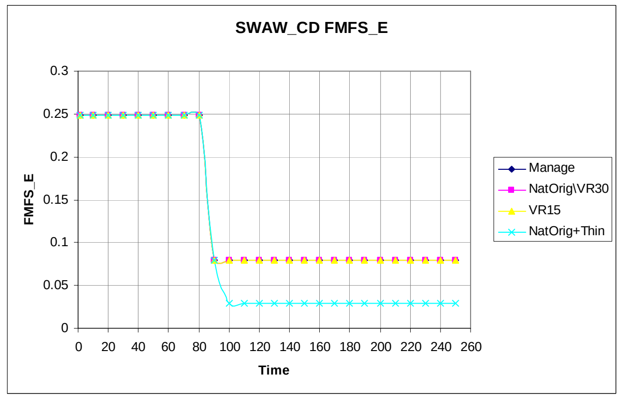
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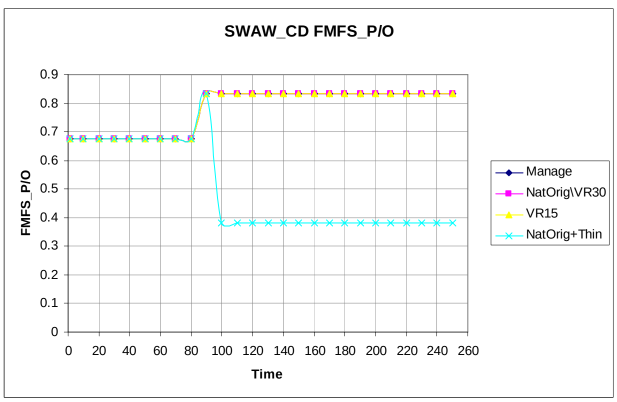
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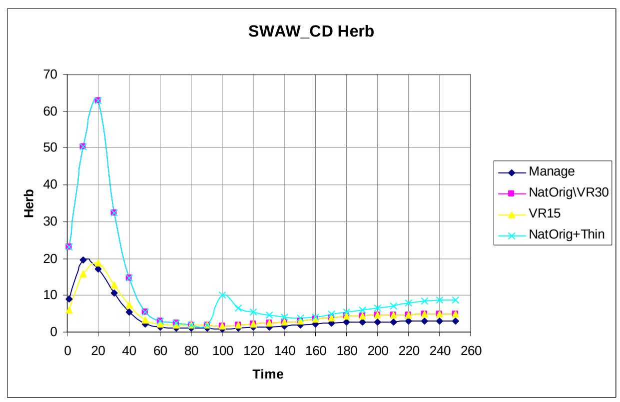
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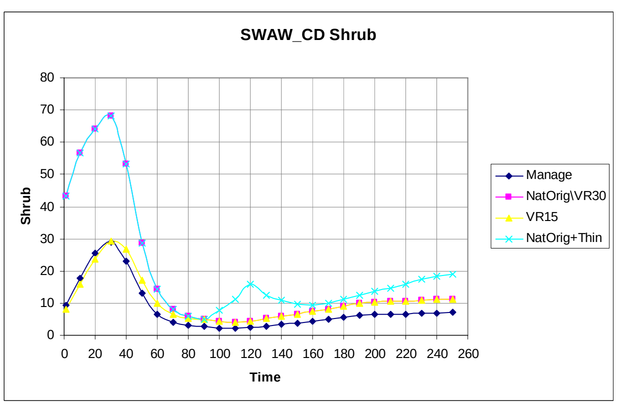
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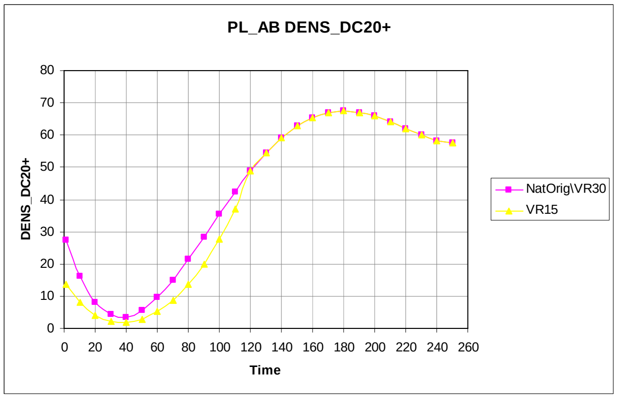
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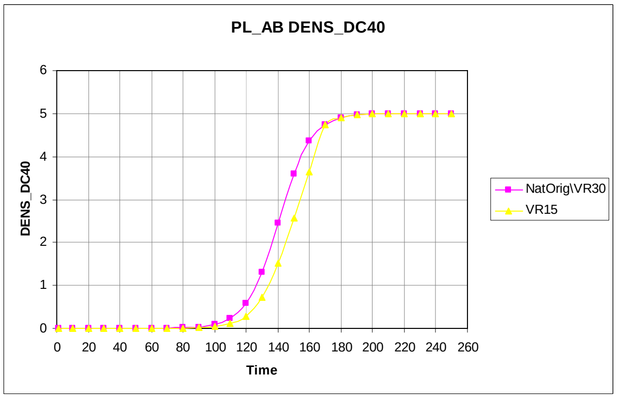
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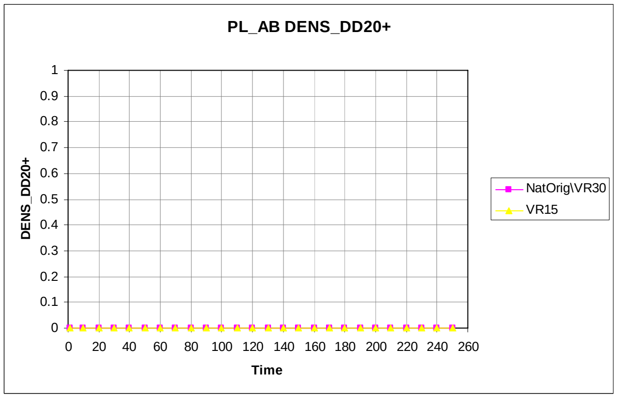
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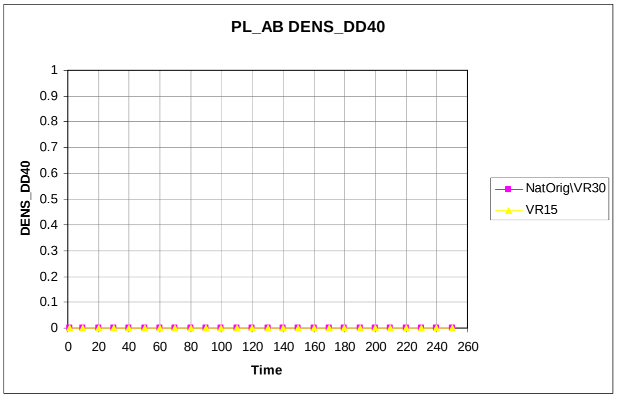
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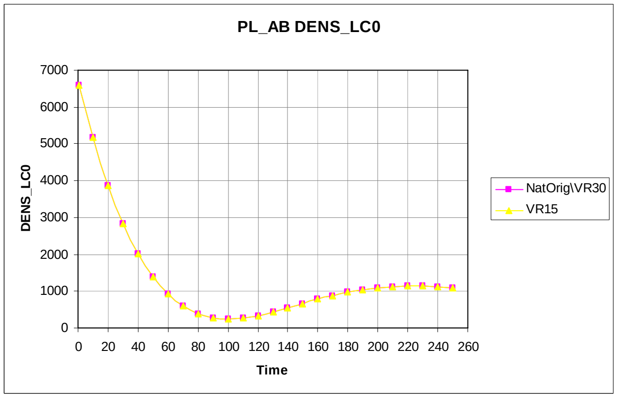
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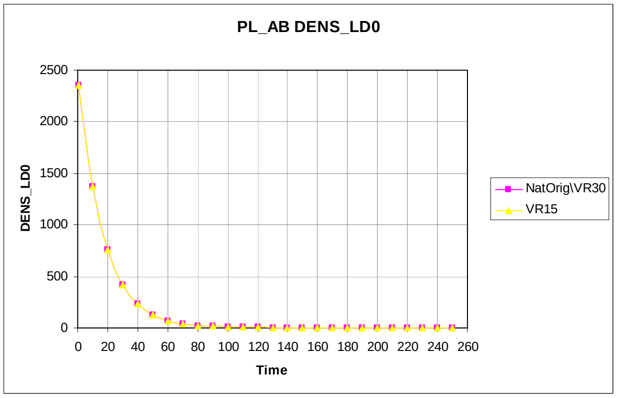
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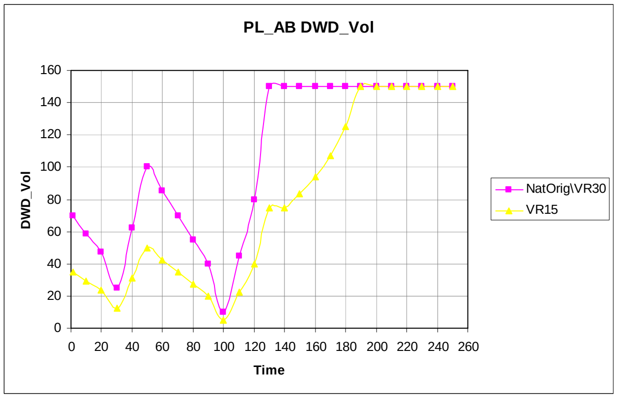
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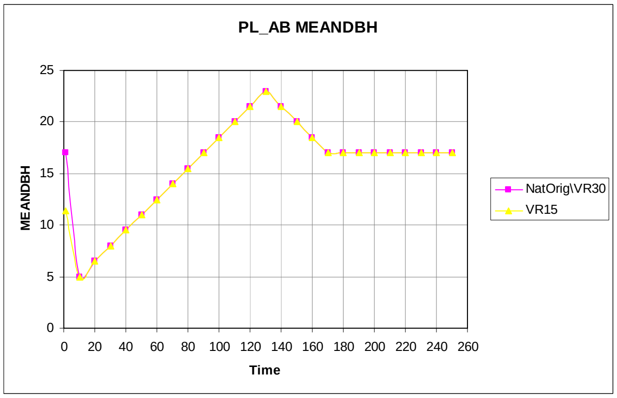
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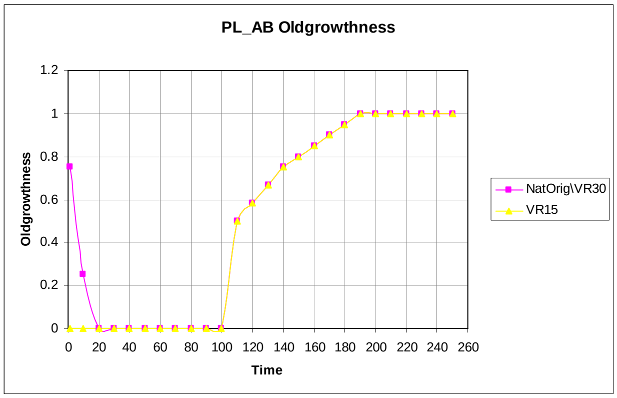
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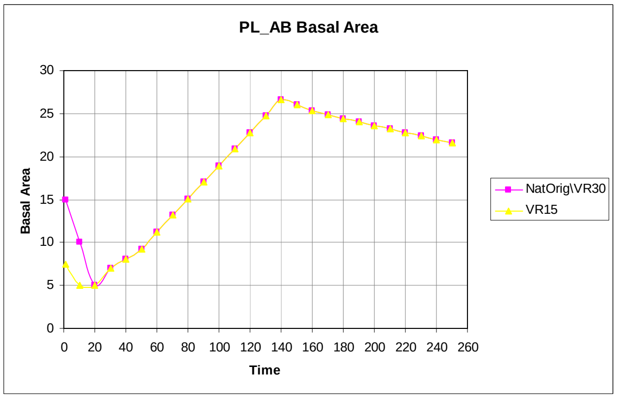
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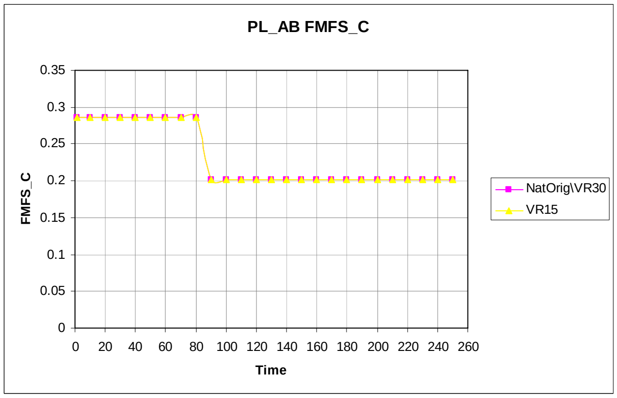
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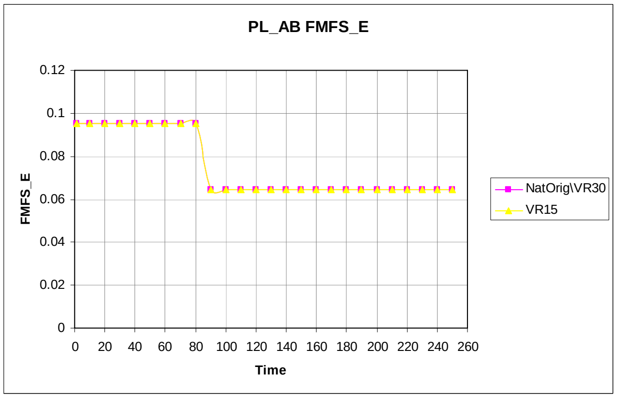
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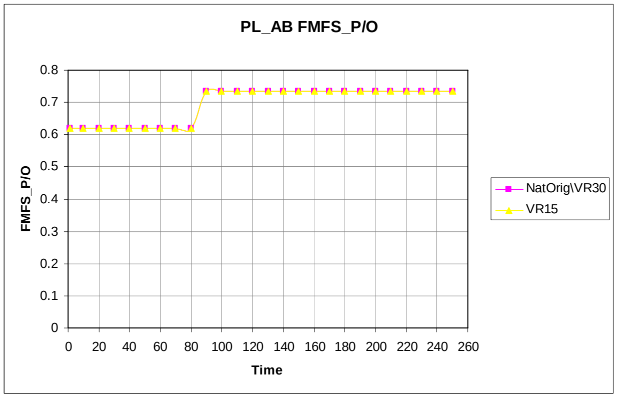
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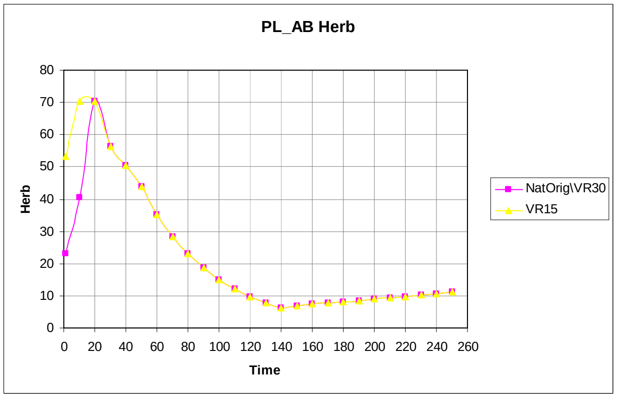
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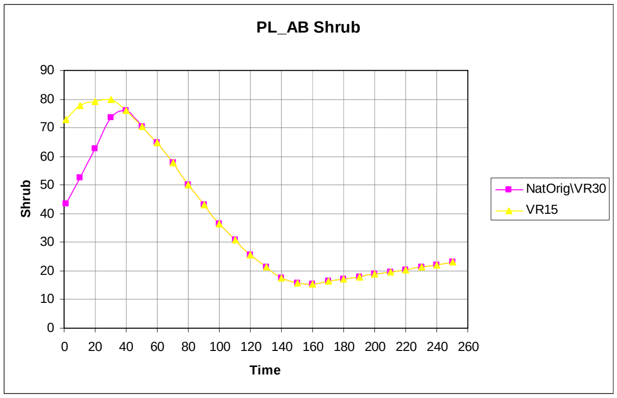
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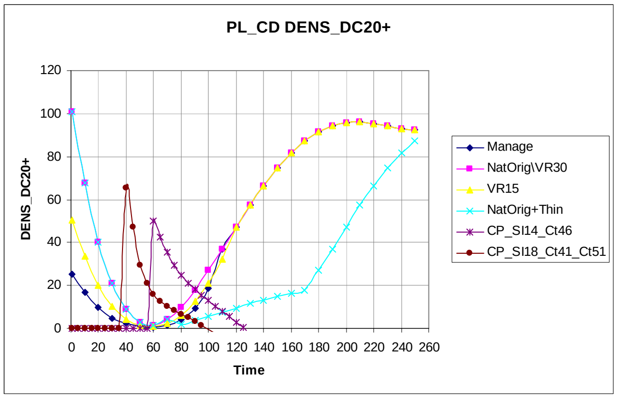
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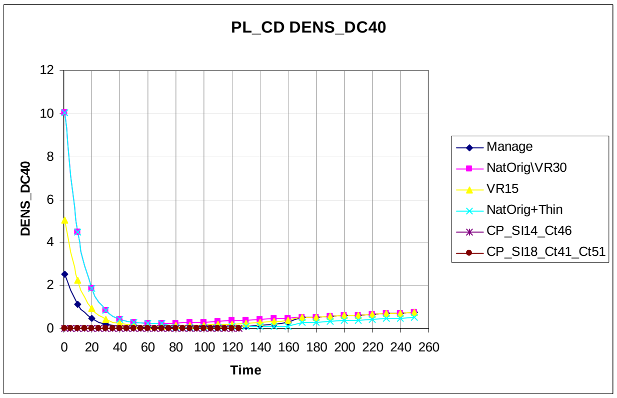
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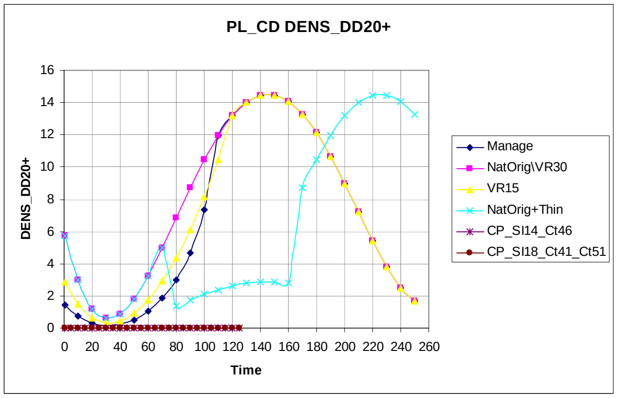
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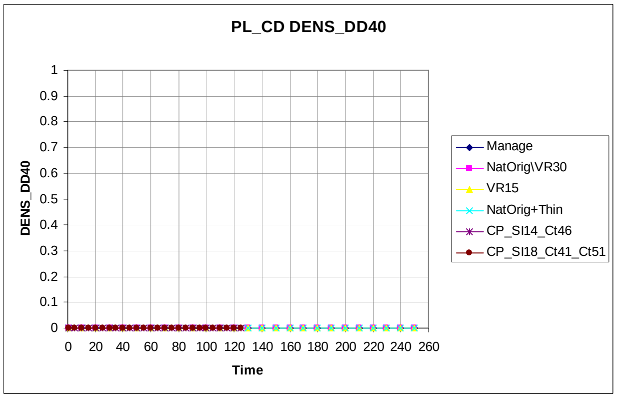
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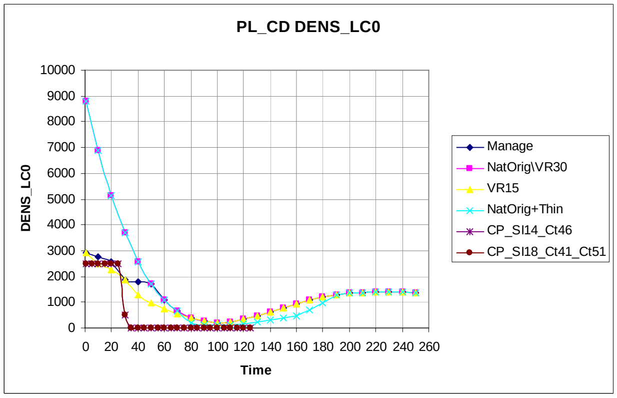
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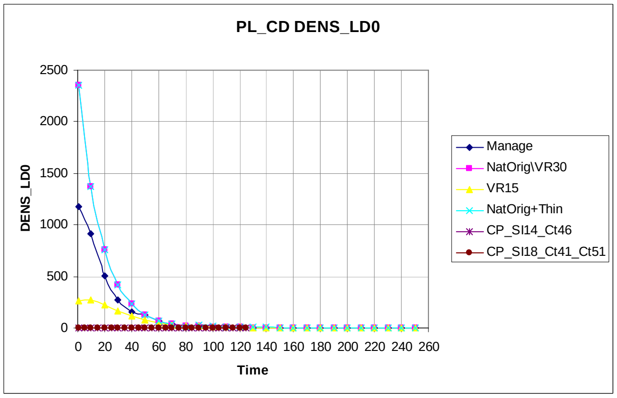
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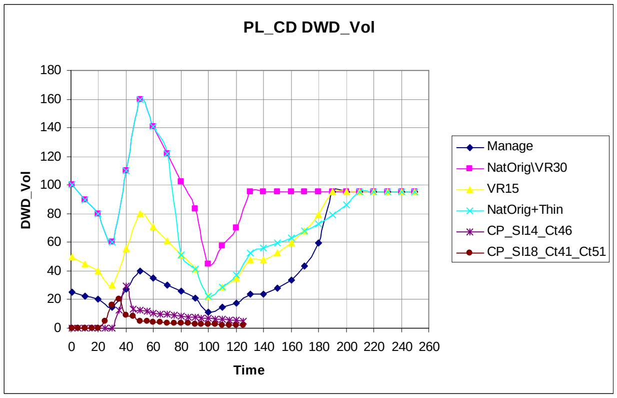
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DWD_Vol
Time
Manage
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VR15
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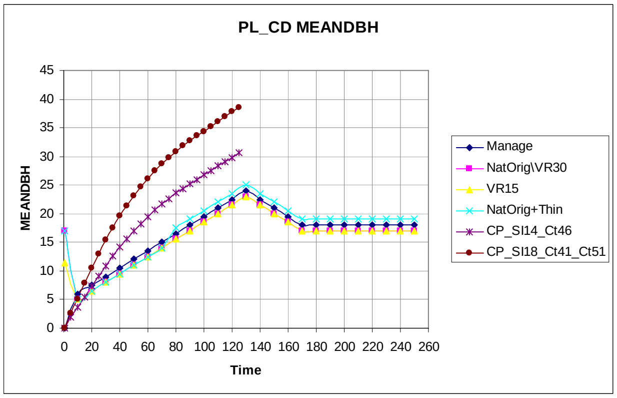
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MEANDBH
Time
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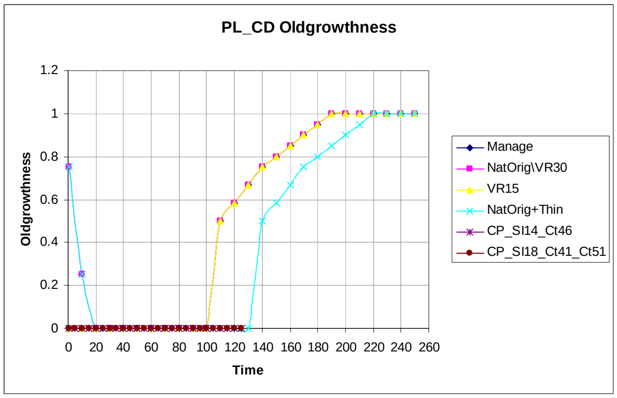
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Time
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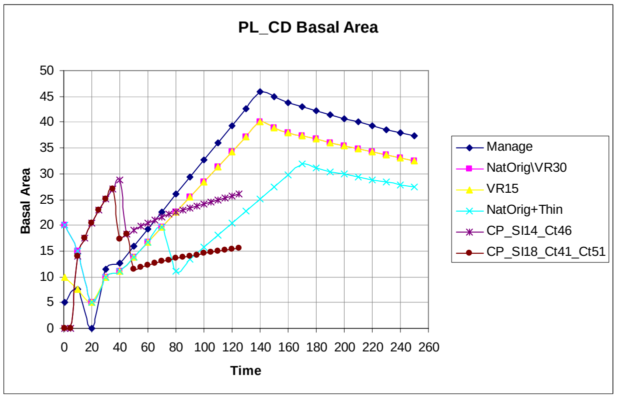
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Time
Manage
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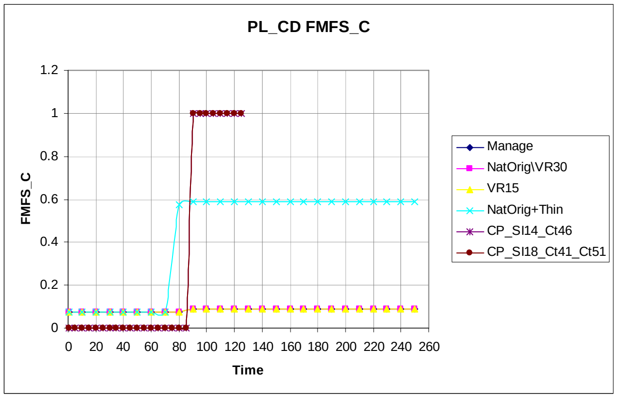
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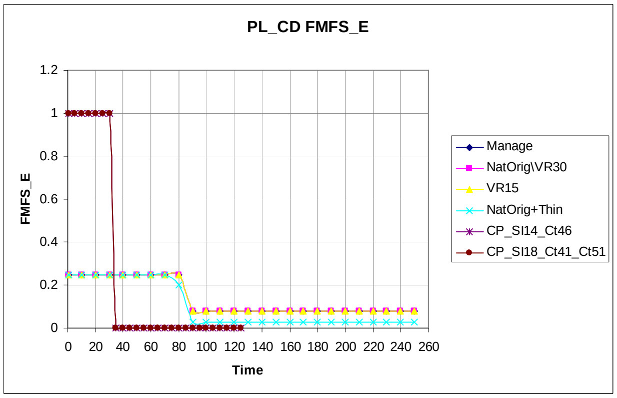
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Time
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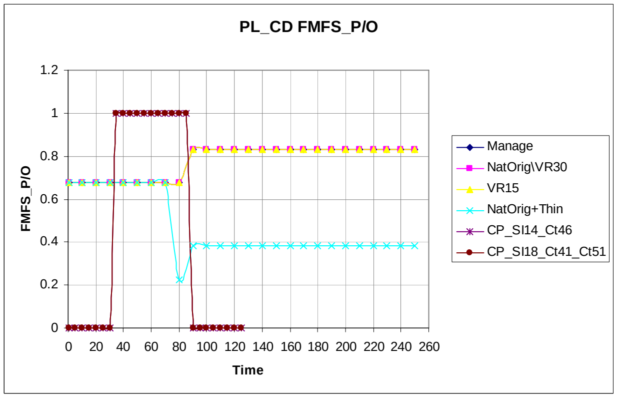
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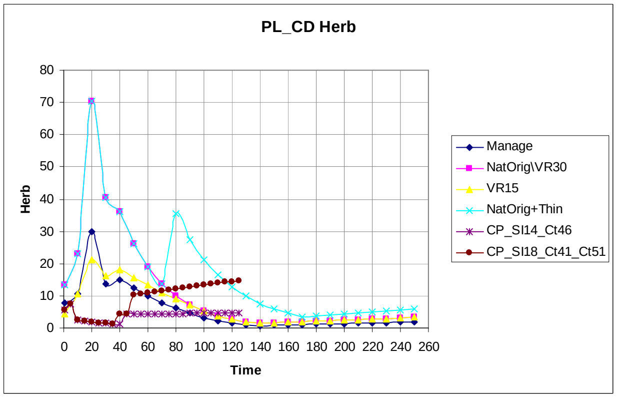
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Herb
Time
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VR15
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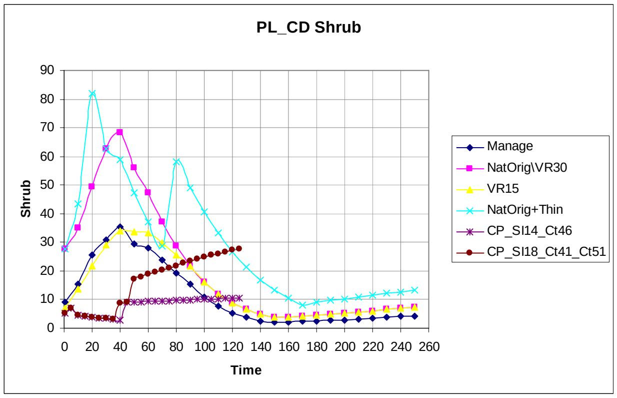
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Shrub
Time
Manage
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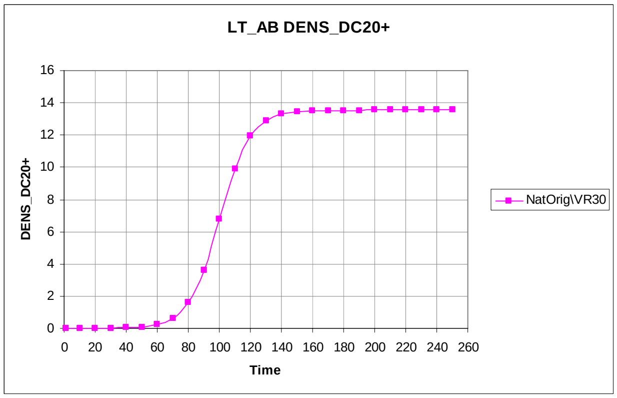
VR15
NatOrig+Thin
CP_SI14_Ct46
CP_SI18_Ct41_Ct51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DENS_DC20+
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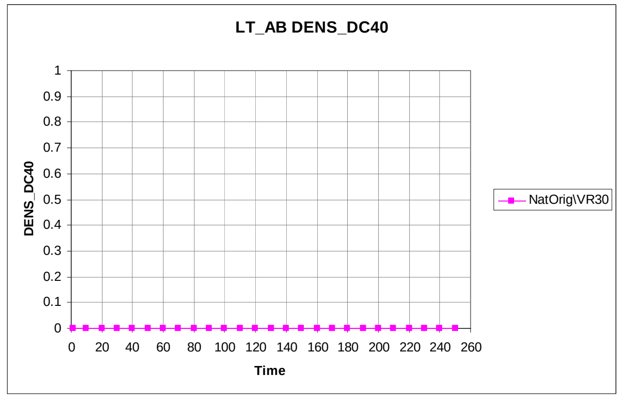
Time
NatOrig\VR30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Time
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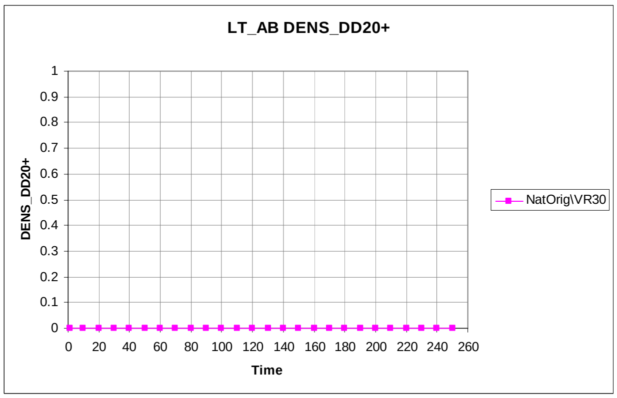
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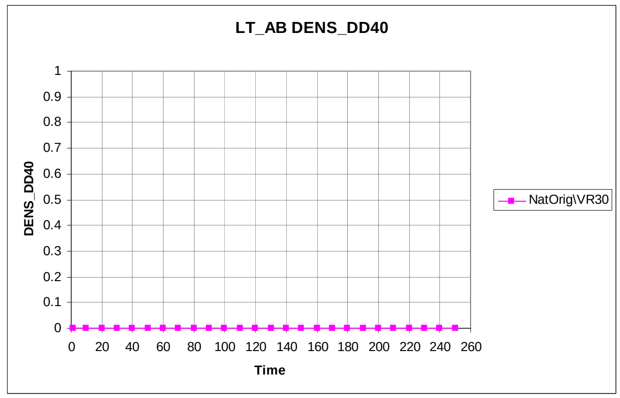
Time
NatOrig\VR30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DENS_DD40
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Time
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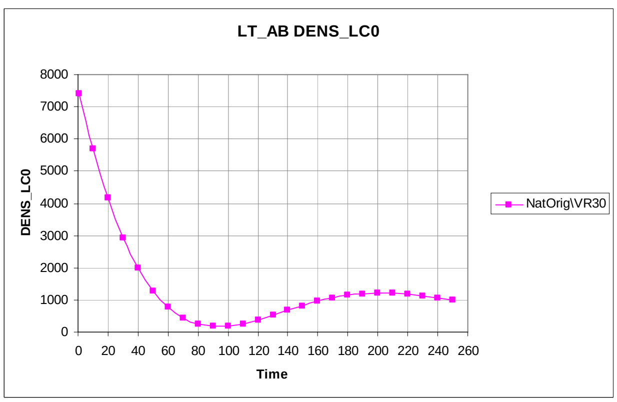
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DENS_LC0
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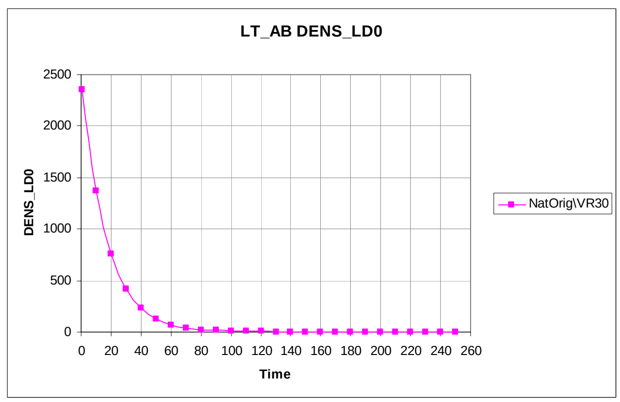
Time
NatOrig\VR30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DENS_LD0
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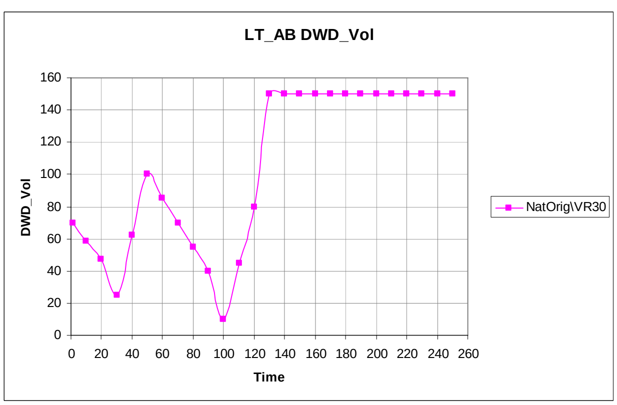
Time
NatOrig\VR30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DWD_Vol
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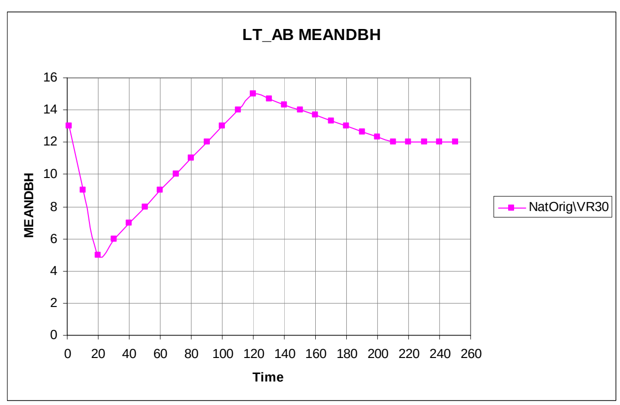
Time
NatOrig\VR30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MEANDBH
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Time
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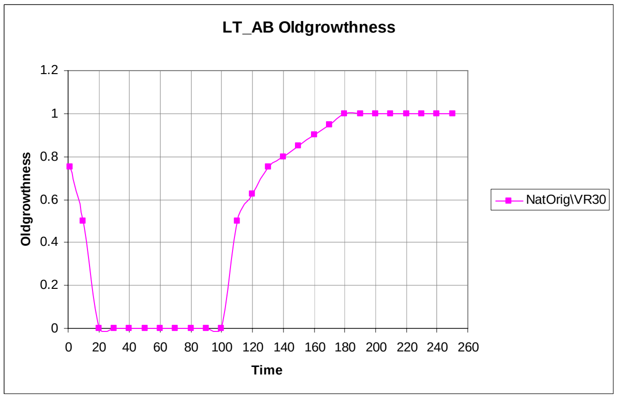
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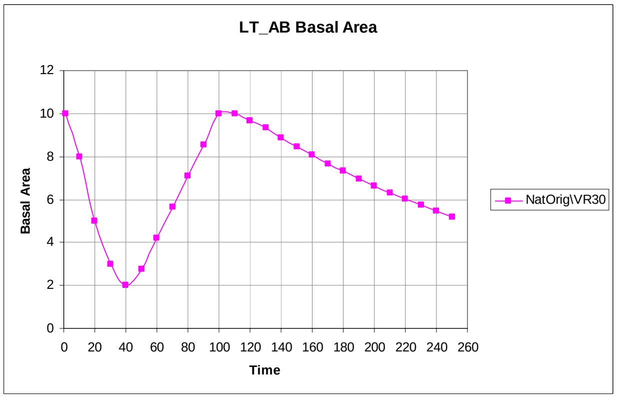
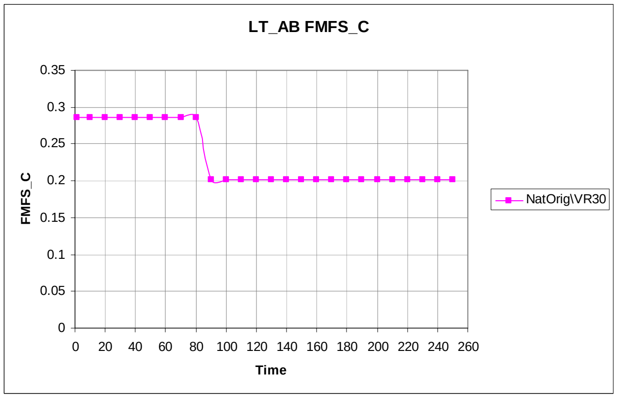
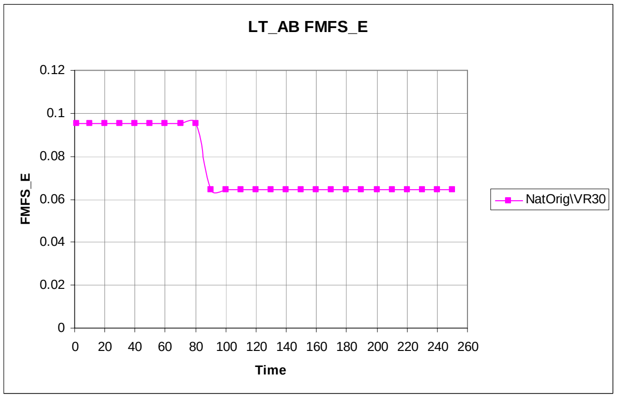
Oldgrowthness
Time
NatOrig\VR30


LT_AB Basal Area
Basal Area
Time
NatOrig\VR30


LT_AB FMFS_C
FMFS_C
Time
NatOrig\VR30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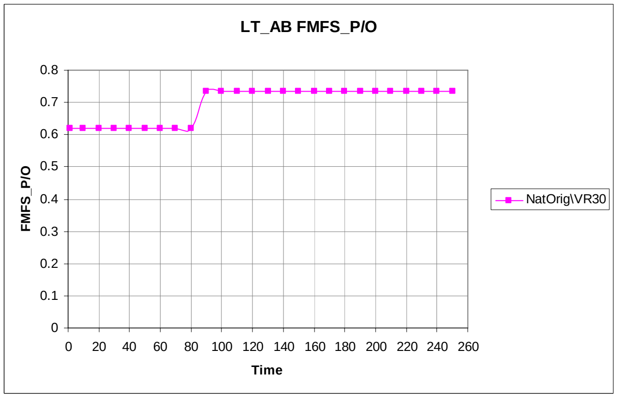
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FMFS_P/O
Time
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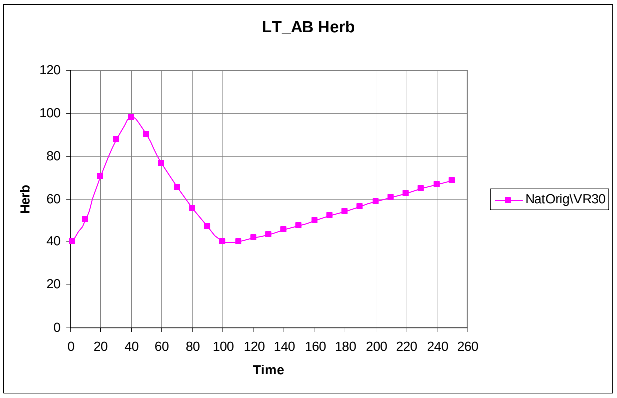
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Herb
Time
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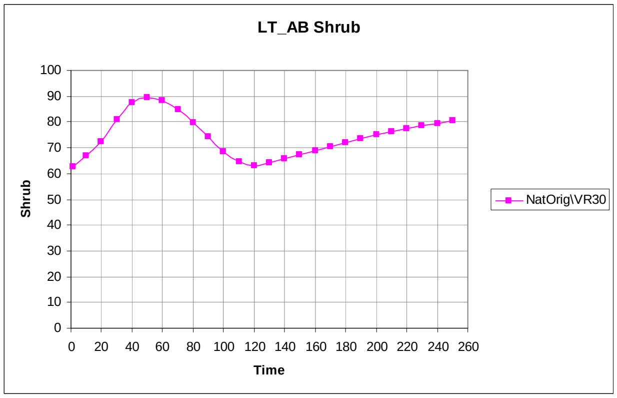
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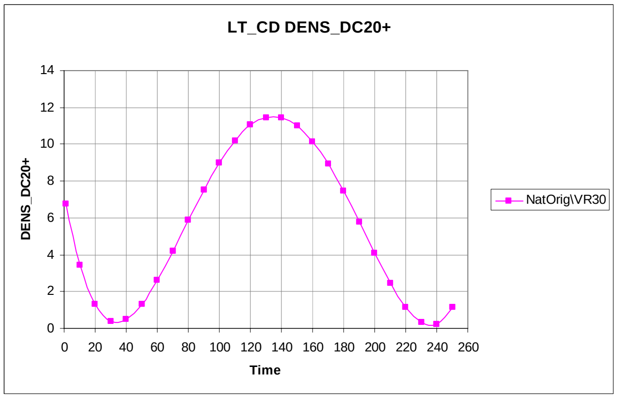
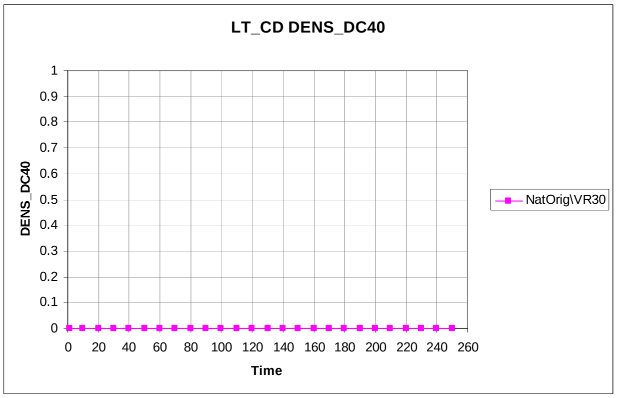
Shrub
Time
NatOrig\VR30


LT_CD DENS_DC20+
DENS_DC20+
Time
NatOrig\VR30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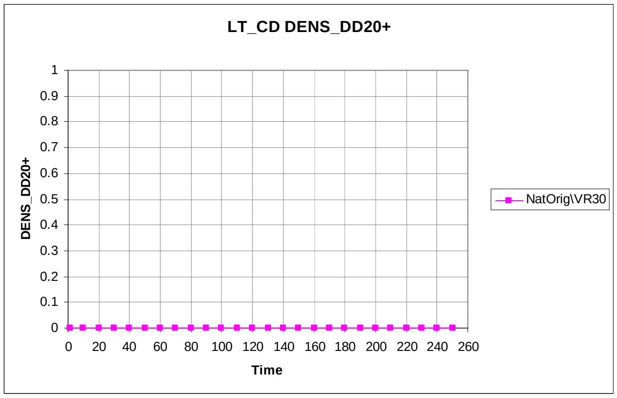
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Time
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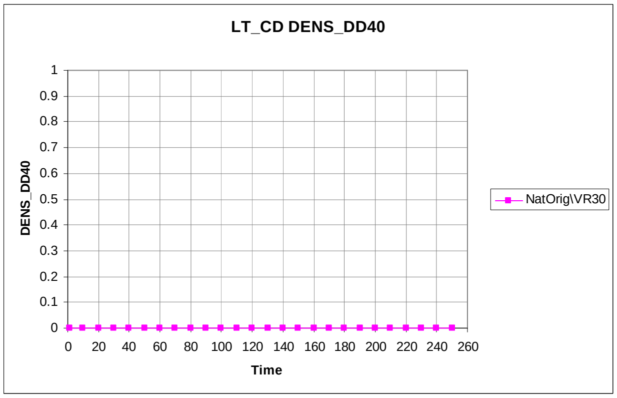
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Time
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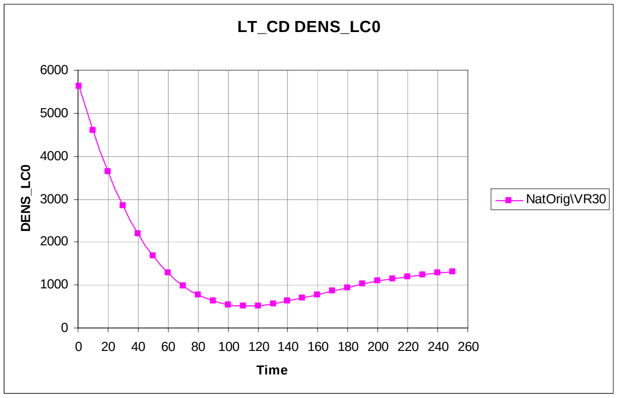
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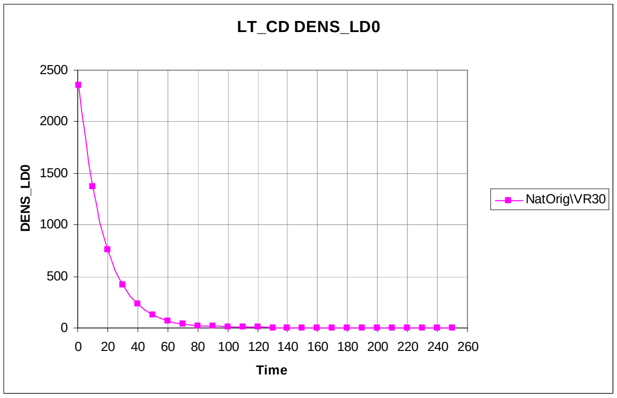
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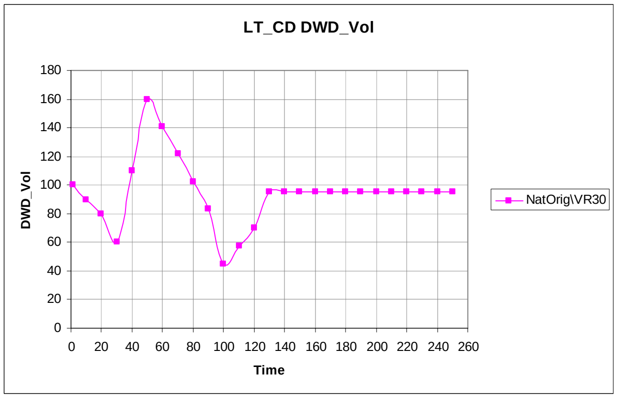
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Time
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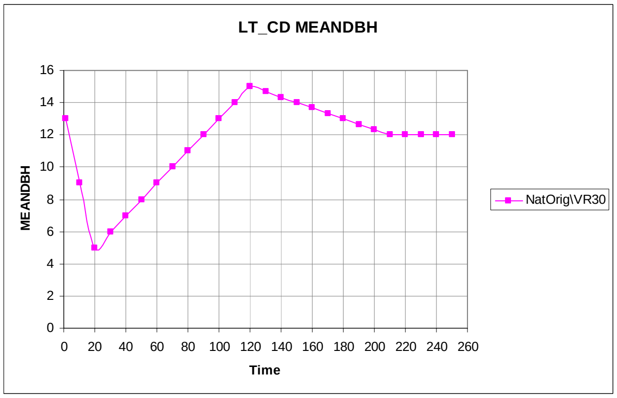
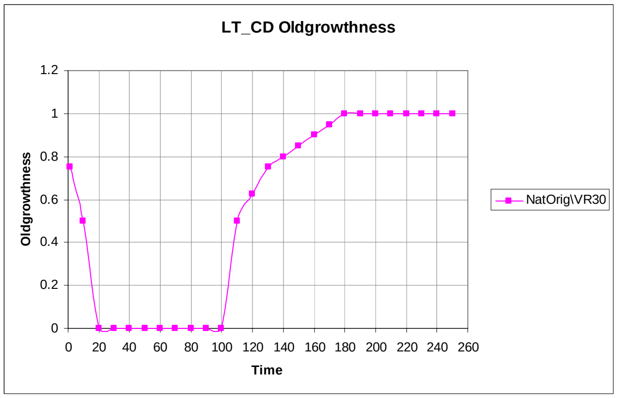
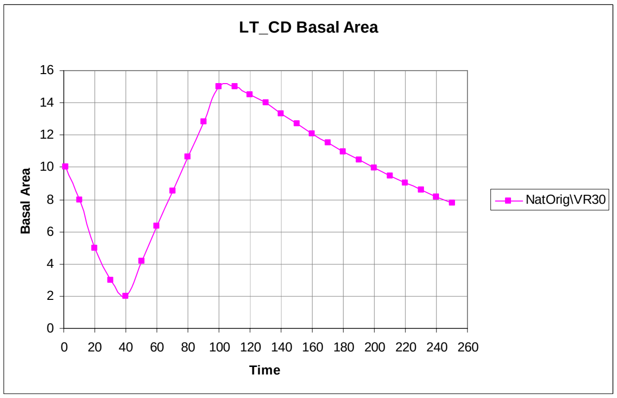
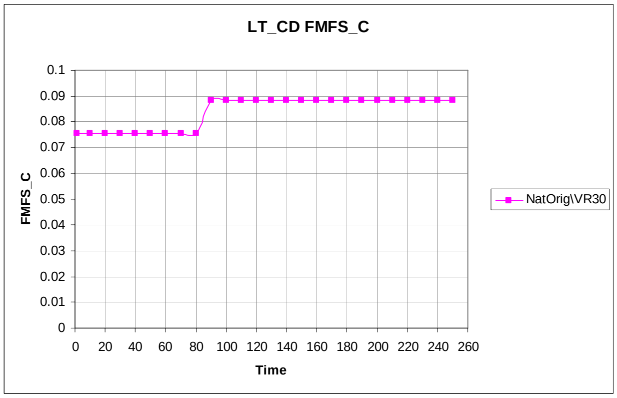

LT_CD MEANDBH
MEANDBH
Time
NatOrig\VR30


LT_CD Oldgrowthness
Oldgrowthness
Time
NatOrig\VR30


LT_CD Basal Area
Basal Area
Time
NatOrig\VR30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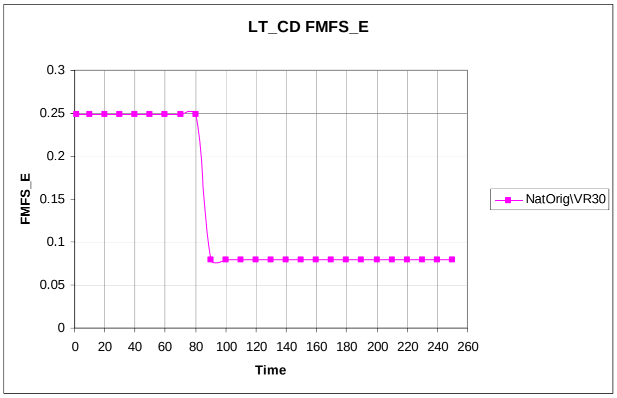
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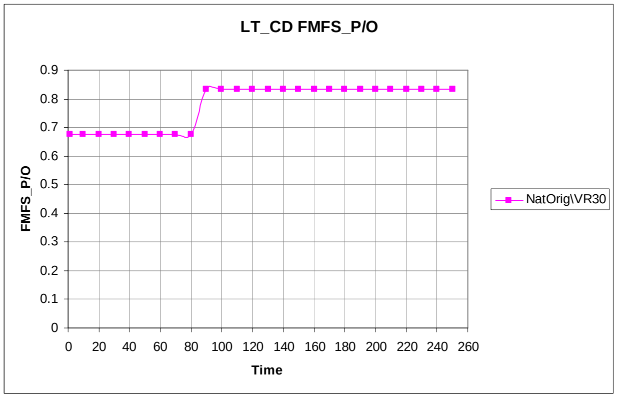
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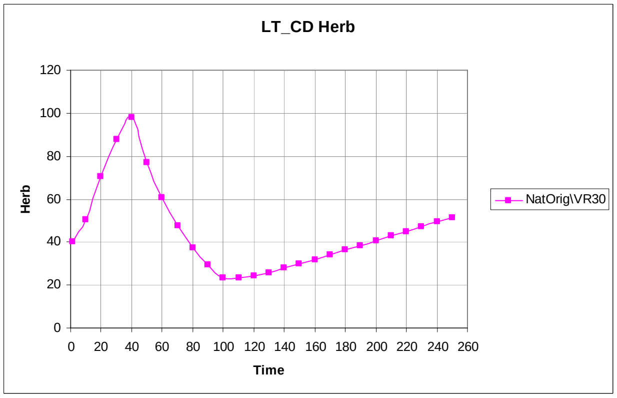
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Herb
Time
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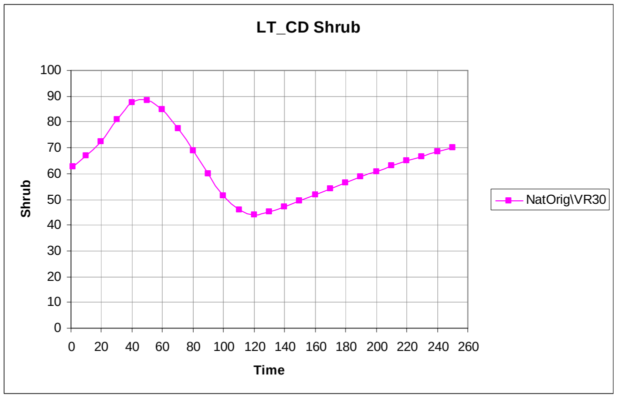
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Shrub
Time
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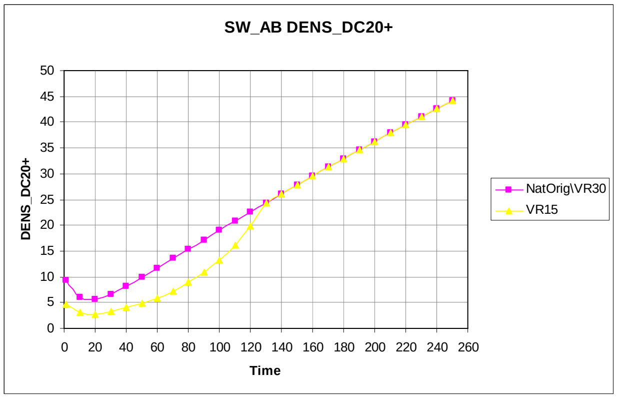
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Time
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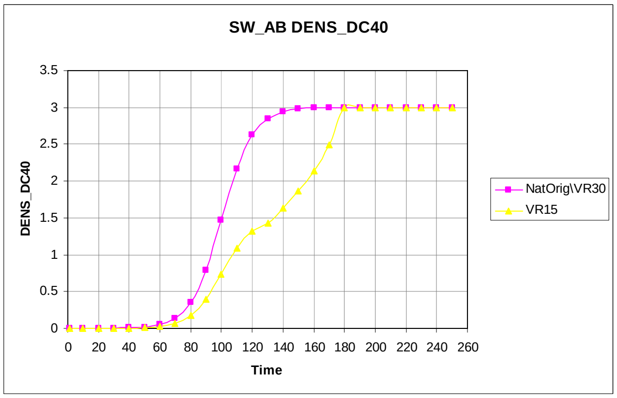
VR15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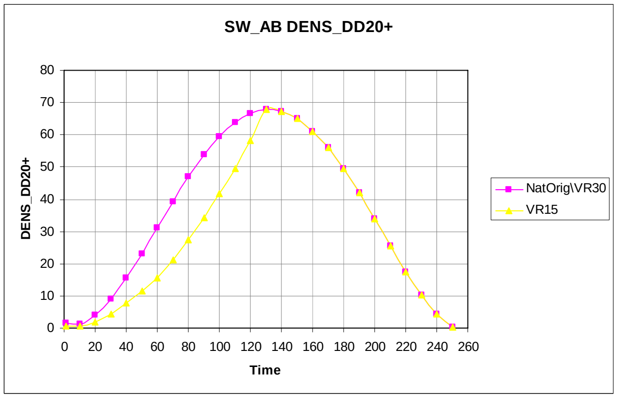
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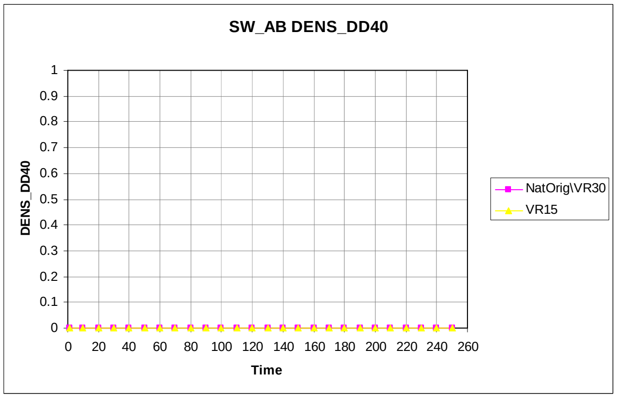
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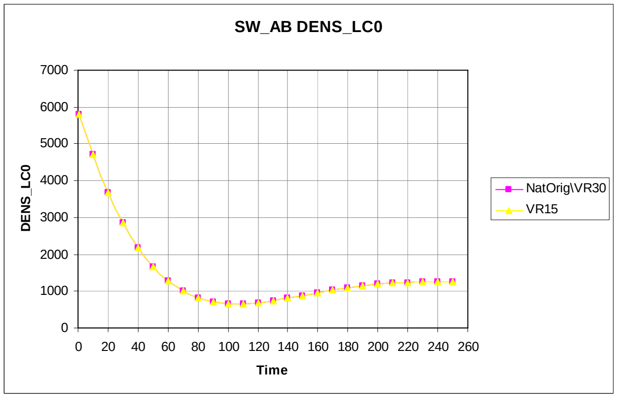
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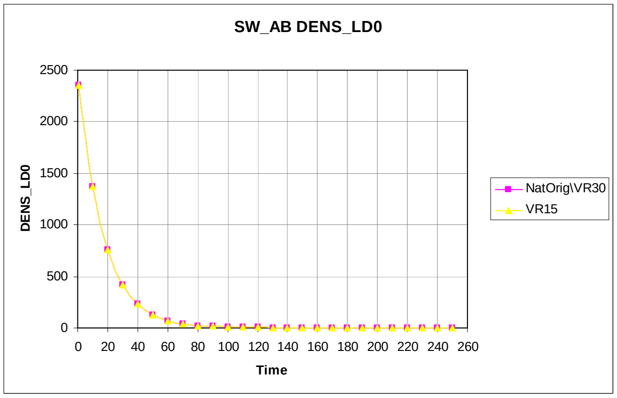
VR15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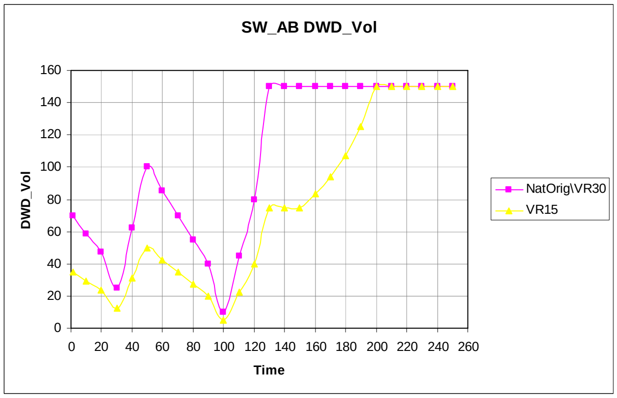
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DWD_Vol
Time
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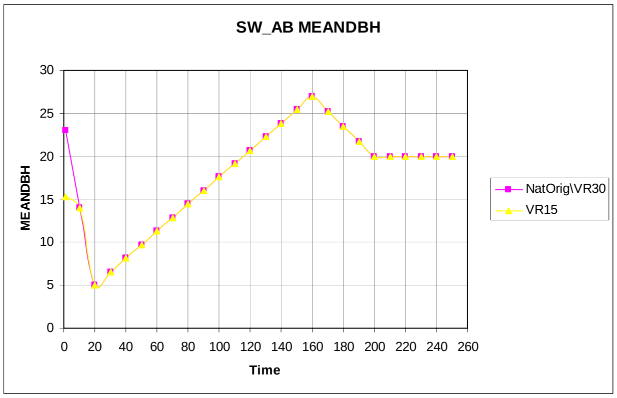
VR15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MEANDBH
Time
NatOrig\VR30
VR15


SW_AB Oldgrowthness
Oldgrowthness
Time
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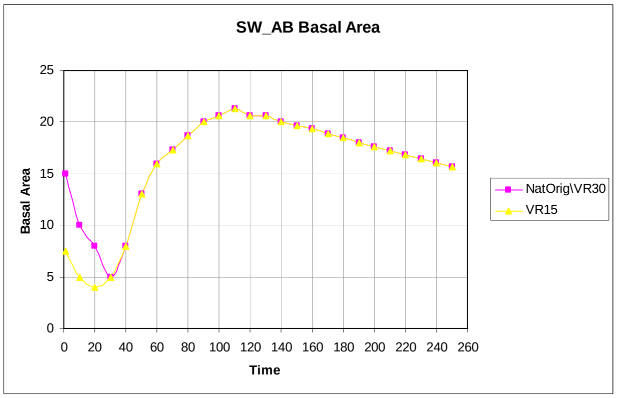
VR15


SW_AB Basal Area
Basal Area
Time
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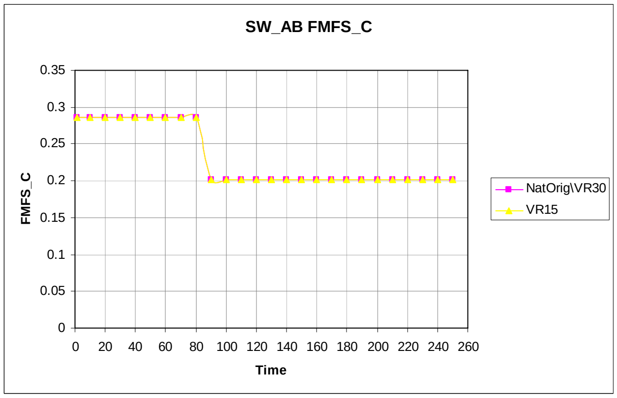
VR15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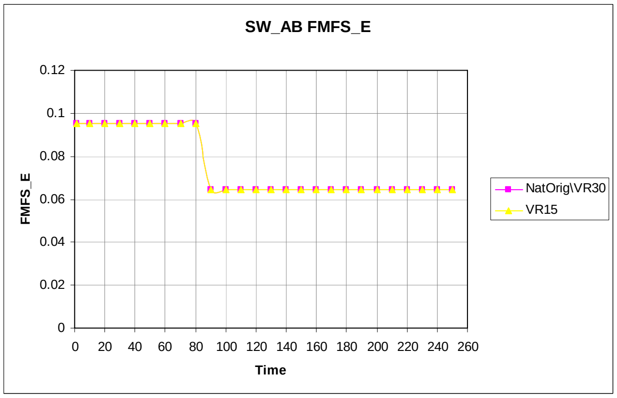
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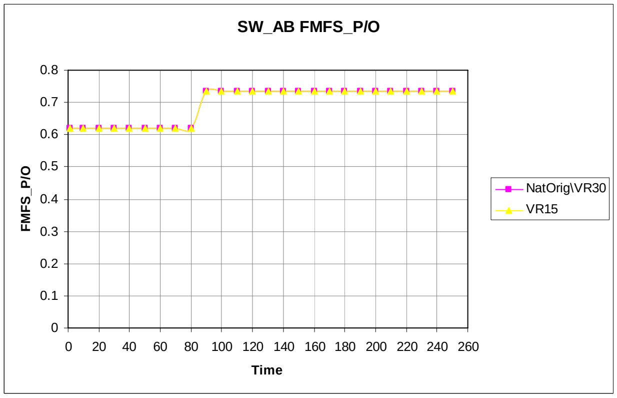
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Time
NatOrig\VR30
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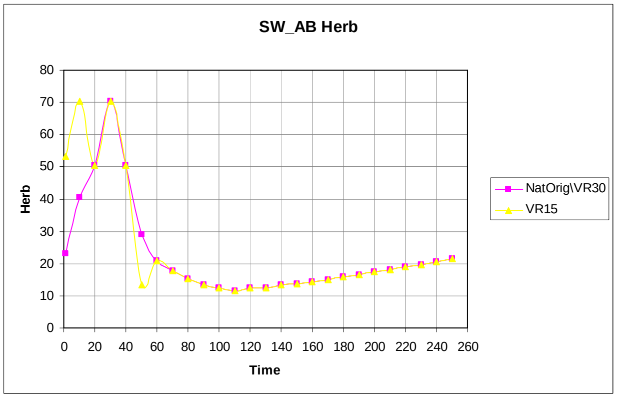
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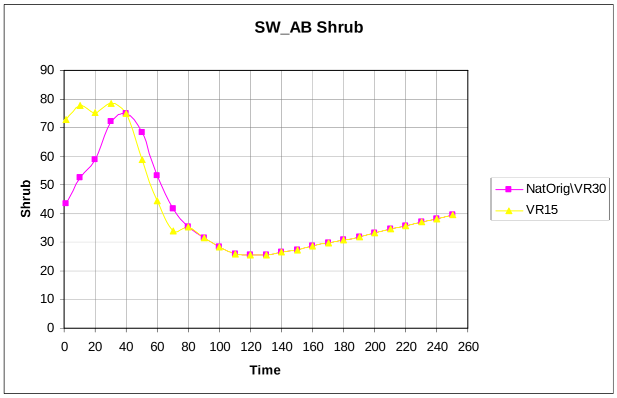
Herb
Time
NatOrig\VR30
VR15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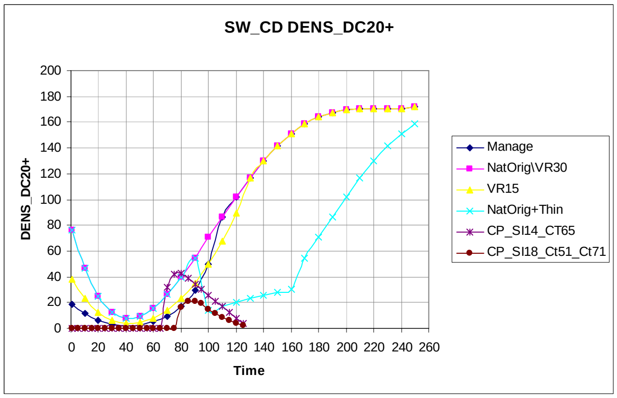
Shrub
Time
NatOrig\VR30
VR15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DENS_DC20+
Time
Manage
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VR15
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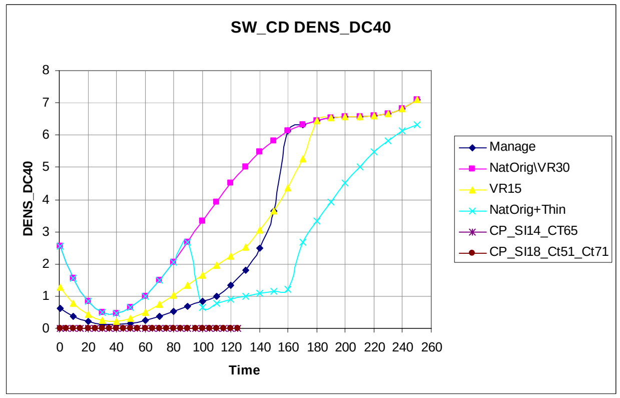
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Time
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VR15
NatOrig+Thin
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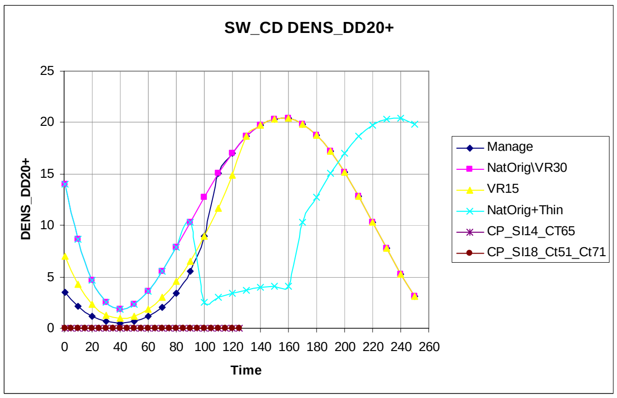
CP_SI18_Ct51_Ct71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DENS_DD20+
Time
Manage
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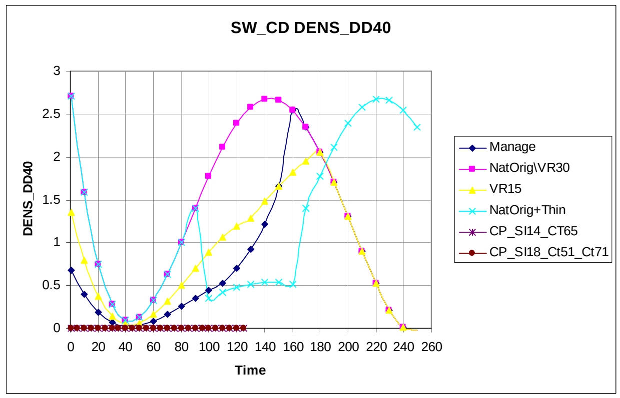
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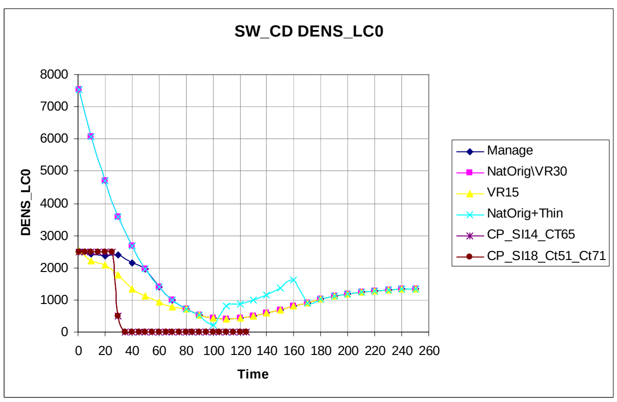
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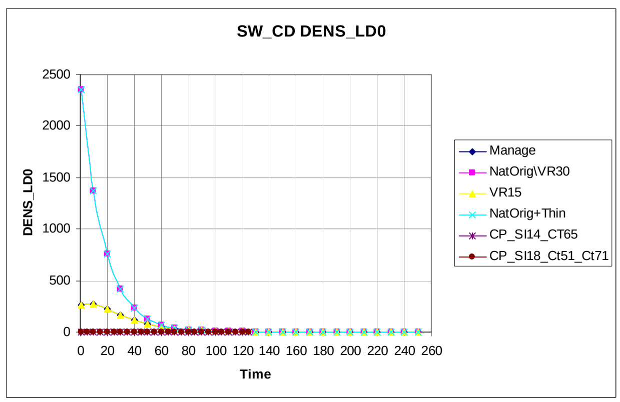
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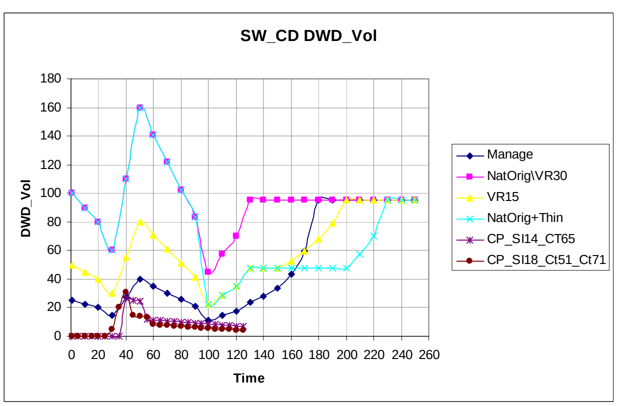
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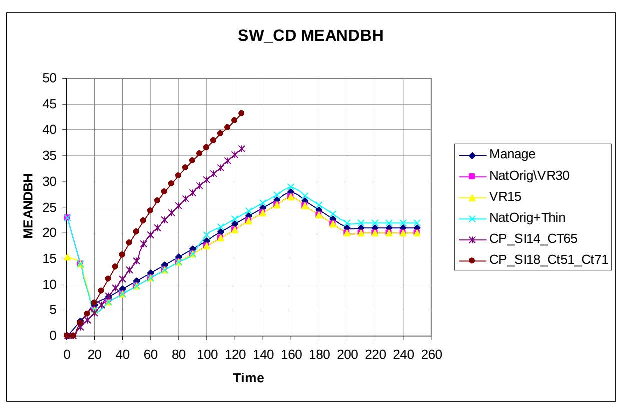
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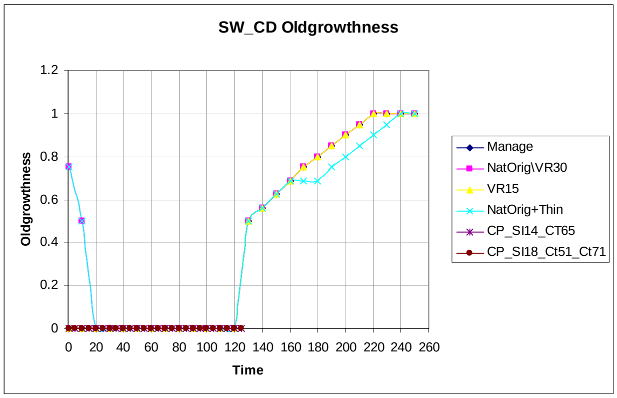
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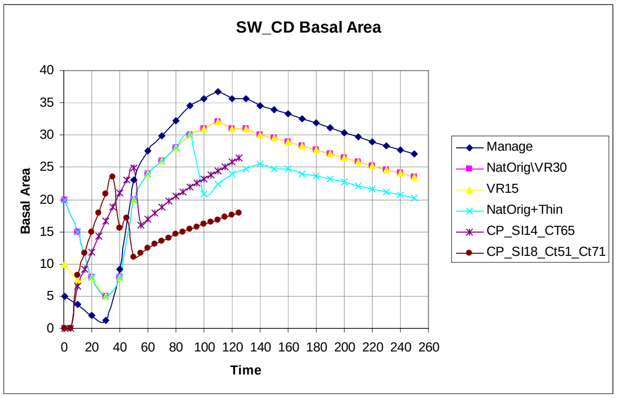
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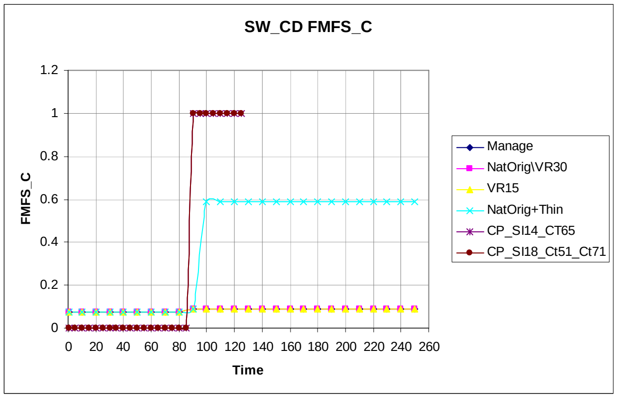
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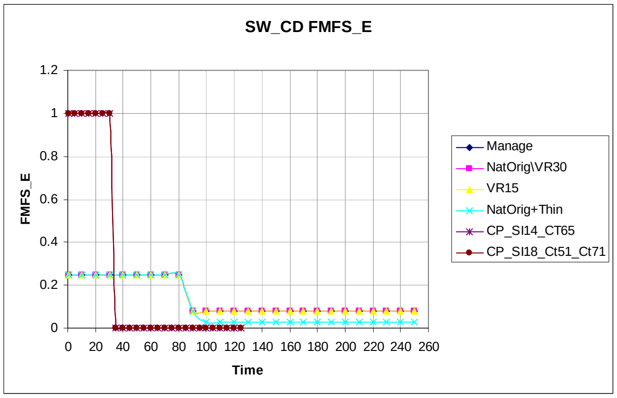
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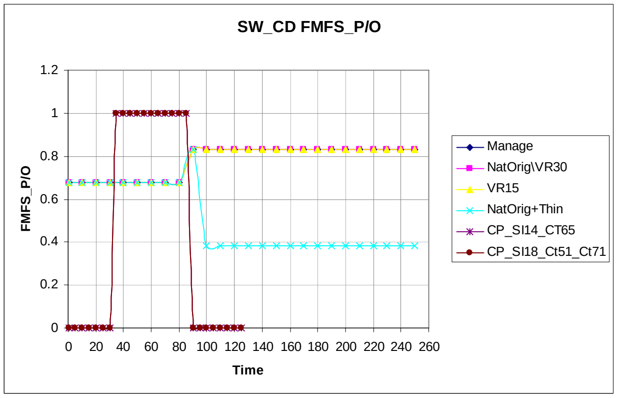
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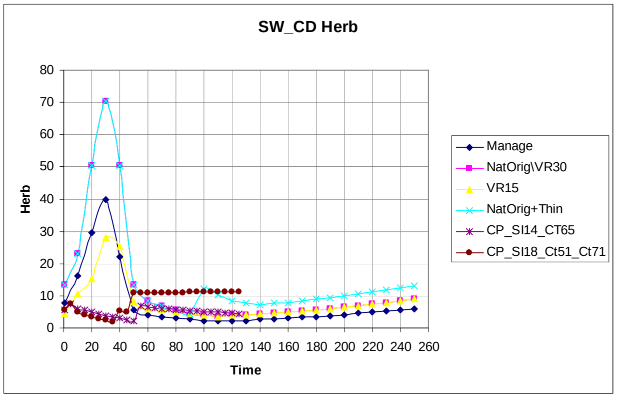
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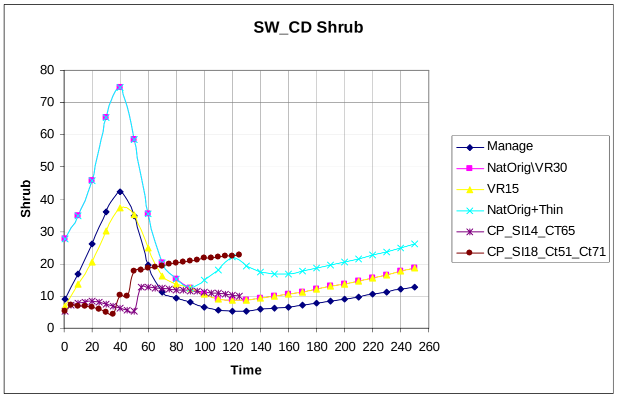
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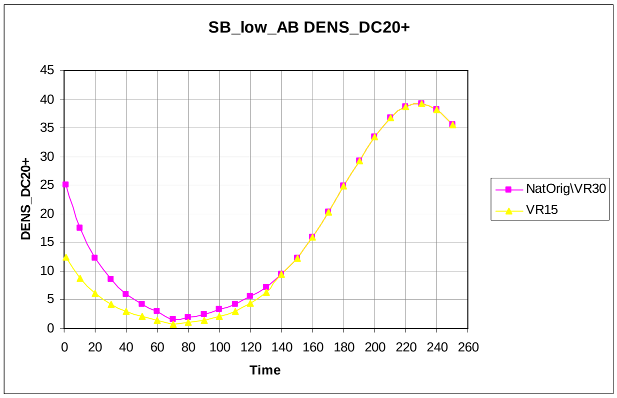
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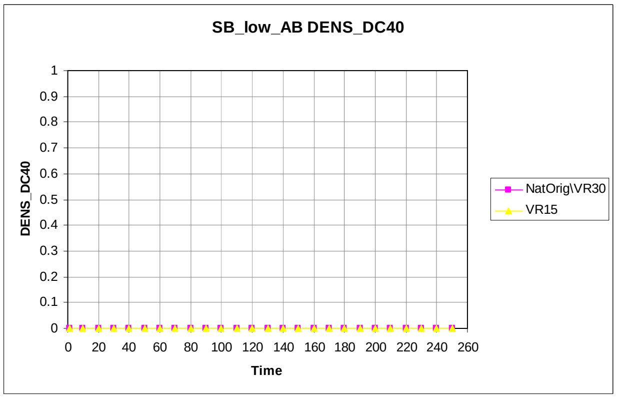
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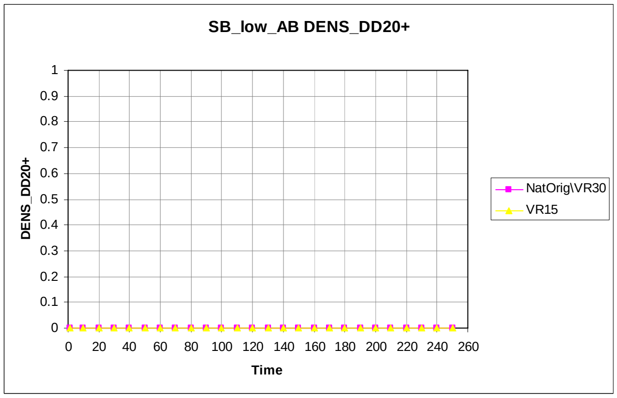
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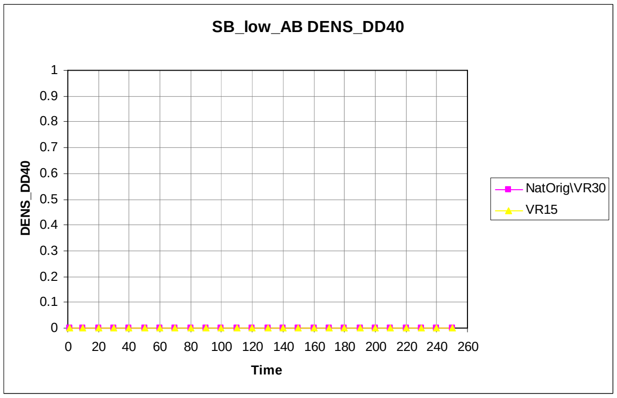
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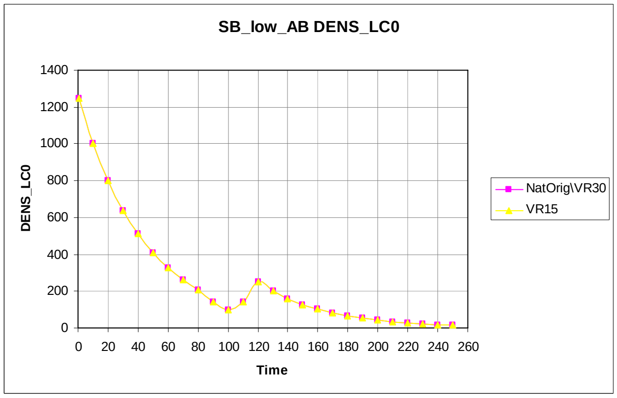
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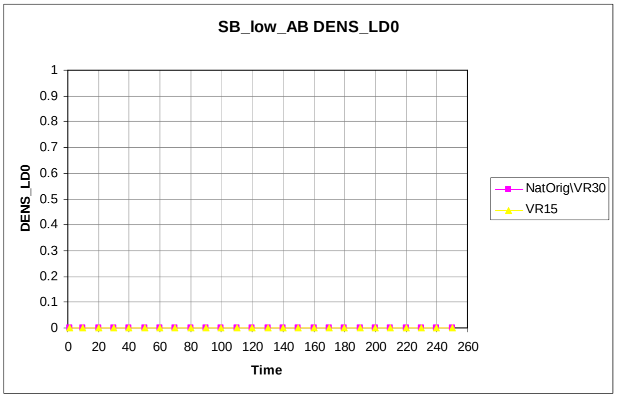
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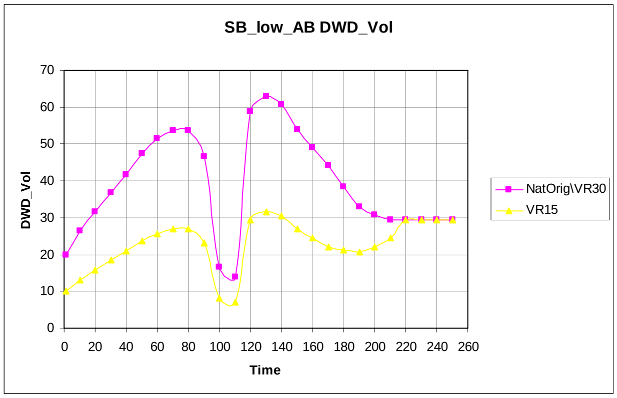
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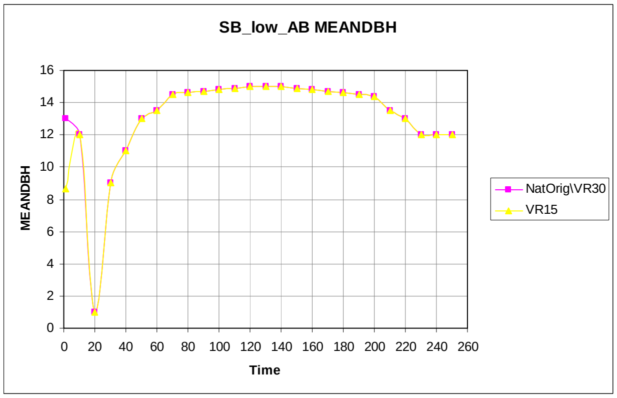
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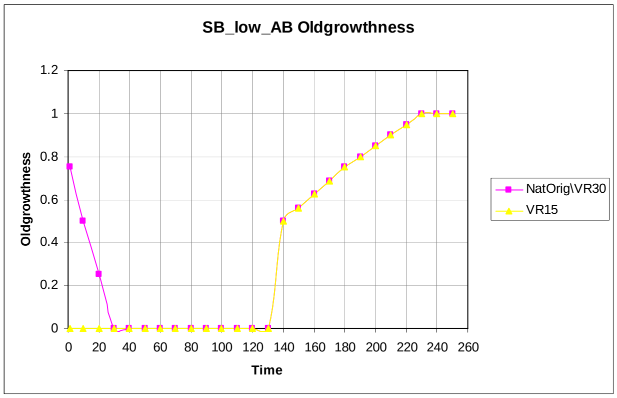
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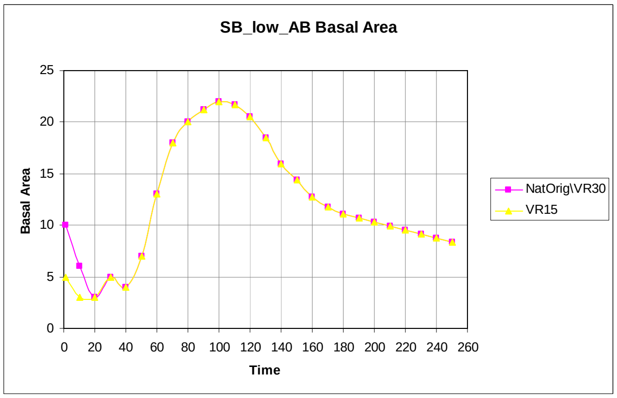
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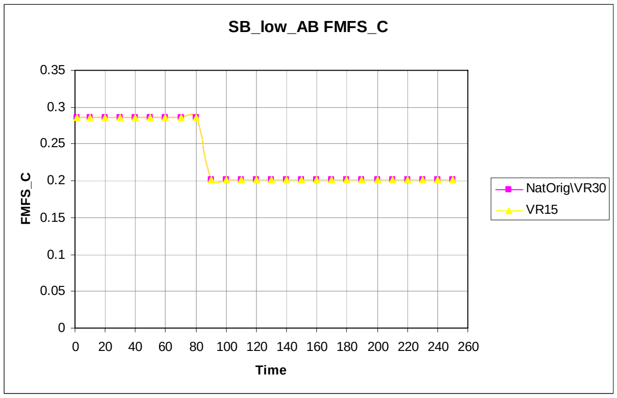
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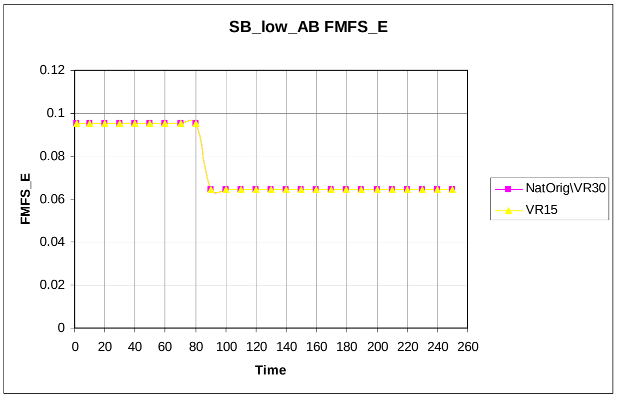
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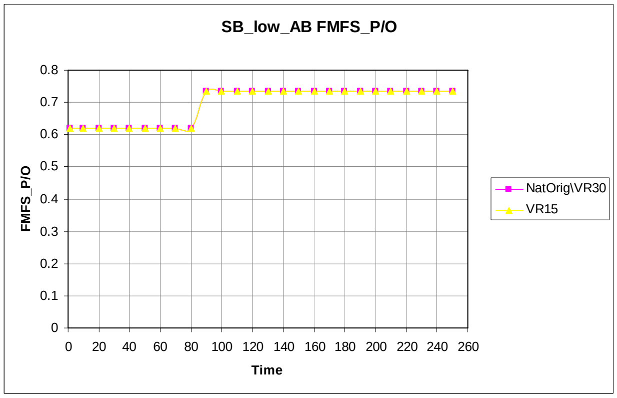
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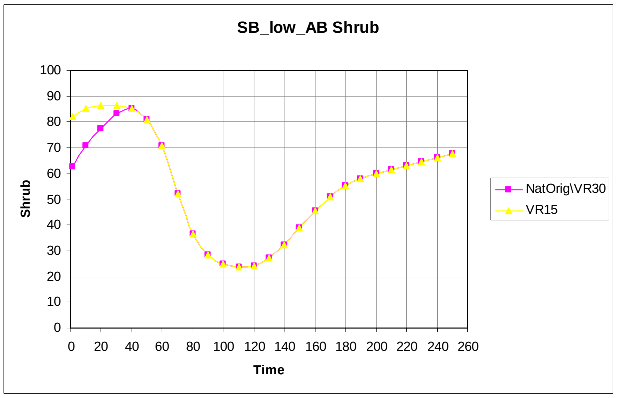
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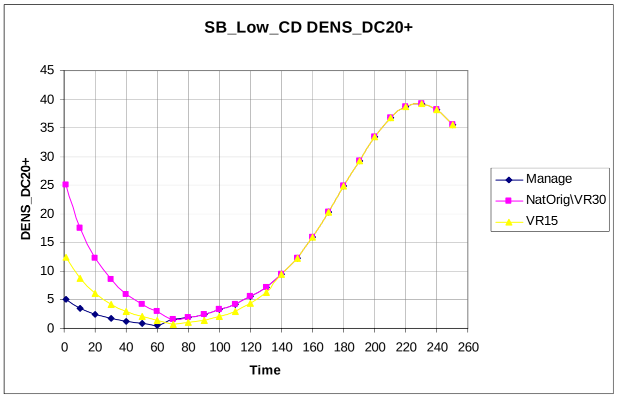
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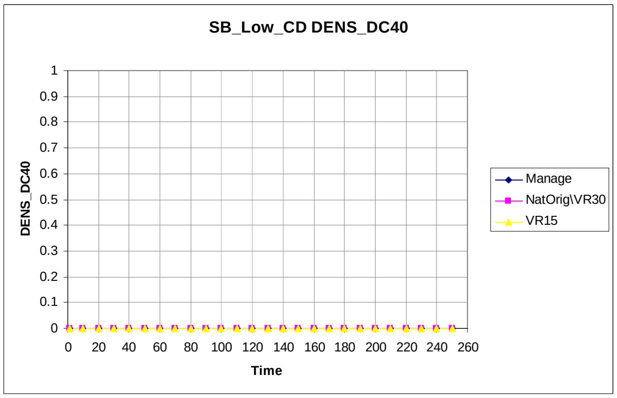
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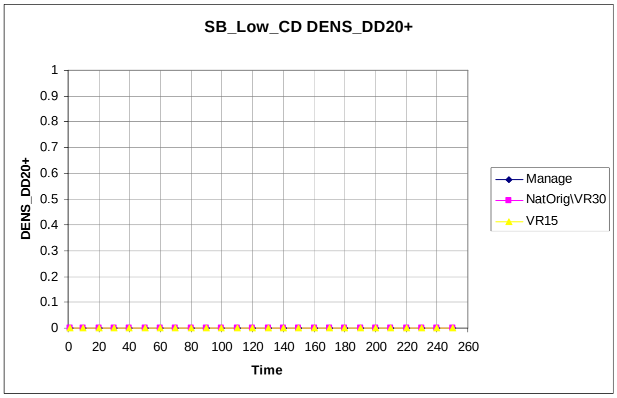
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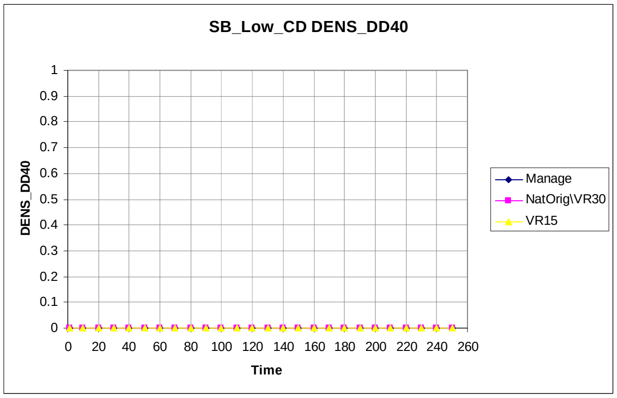
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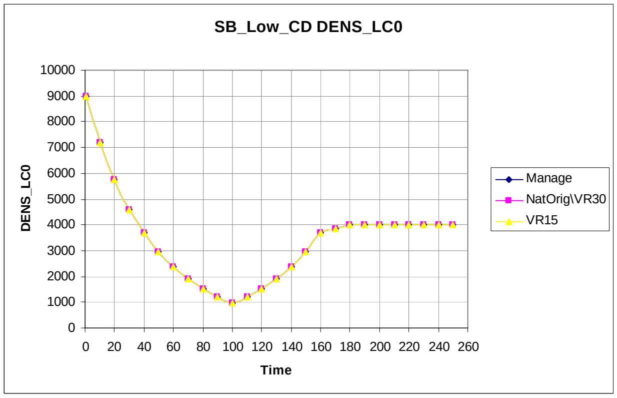
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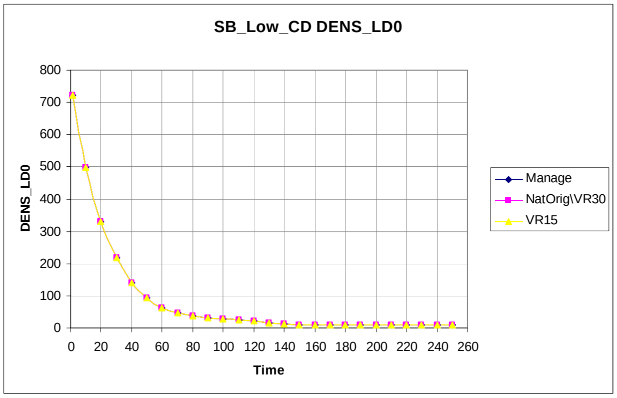
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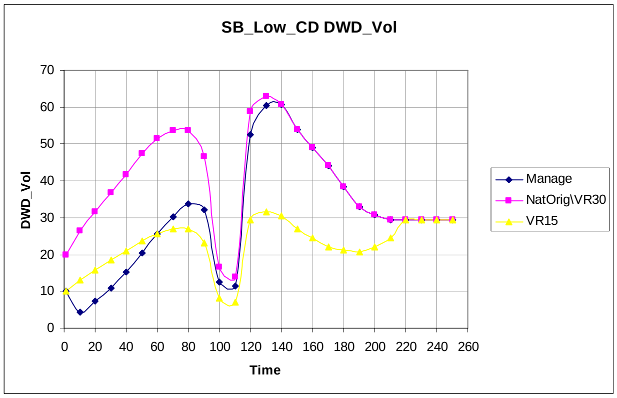
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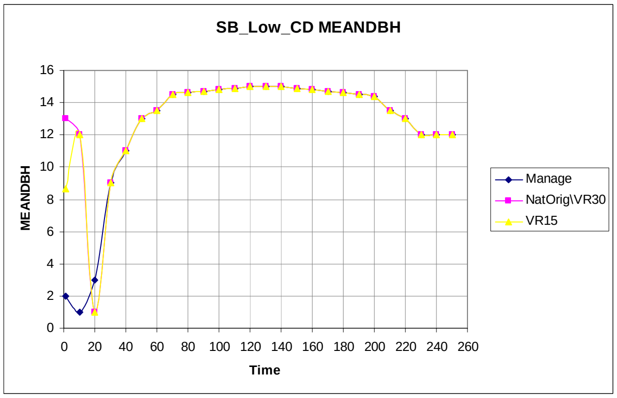
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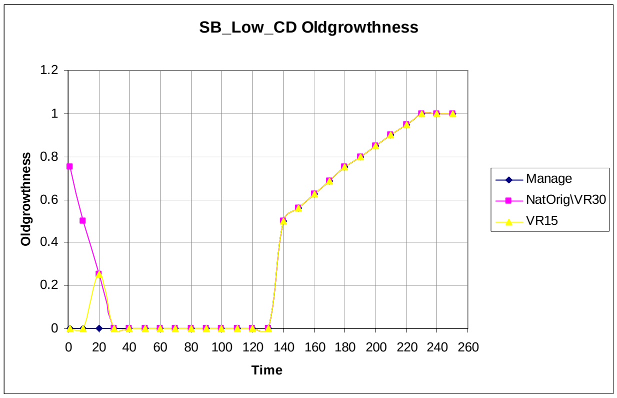
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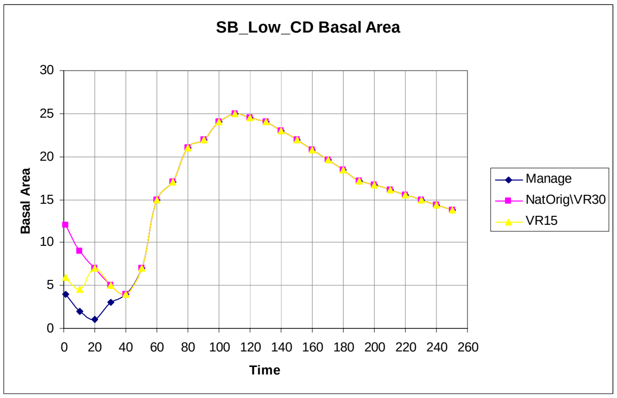
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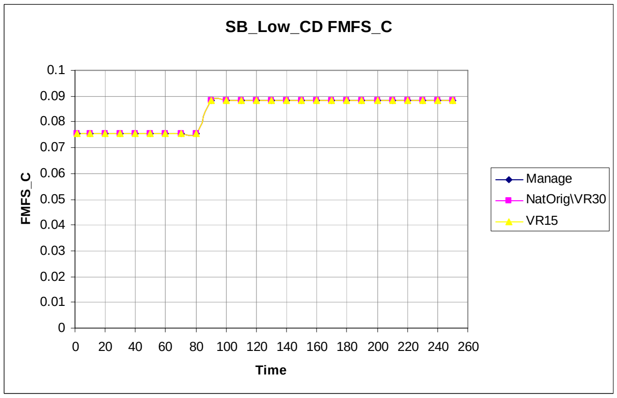
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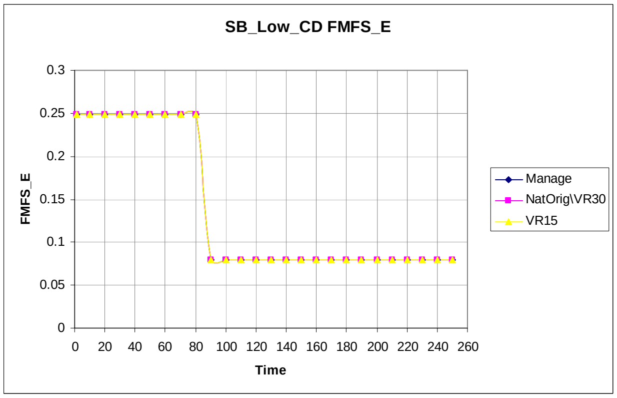
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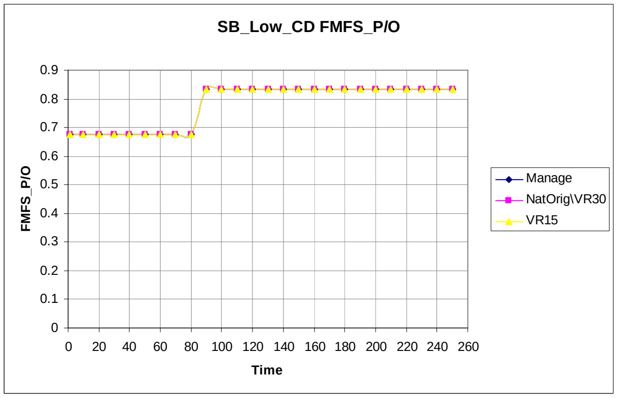
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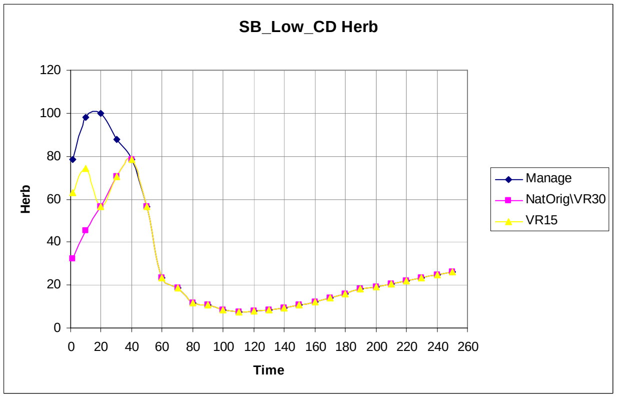
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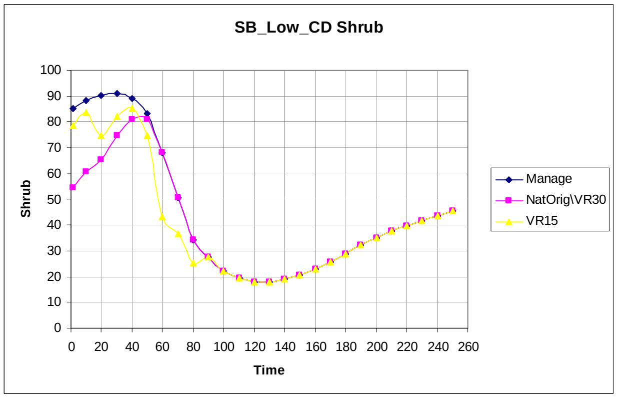
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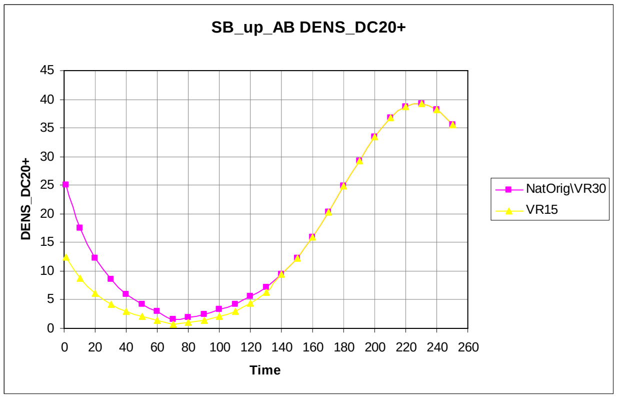
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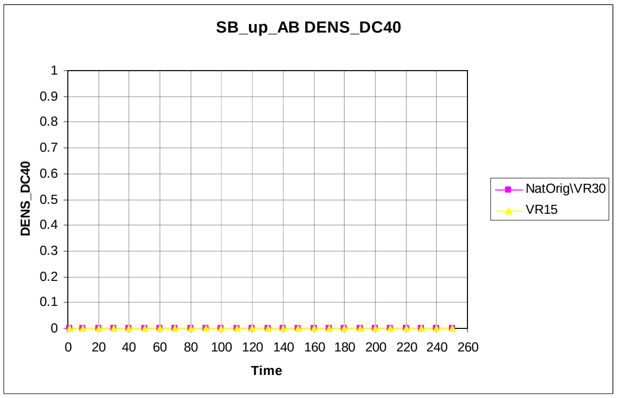
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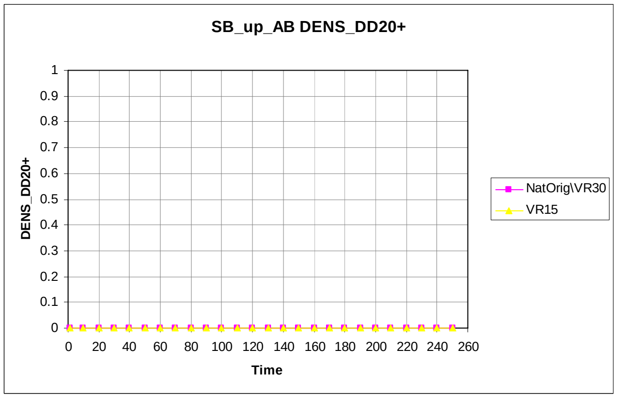
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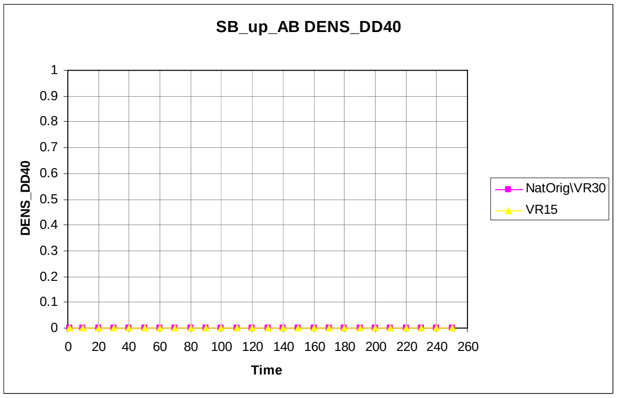
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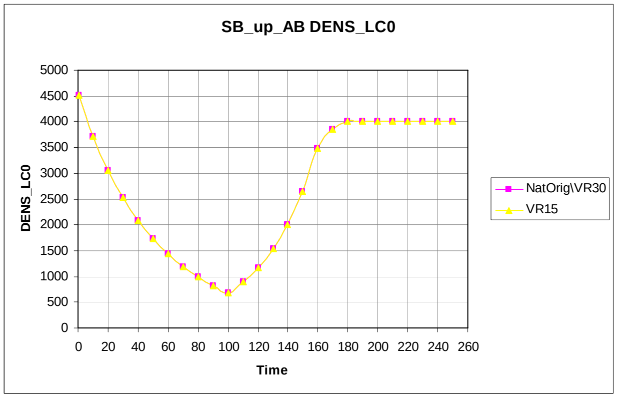
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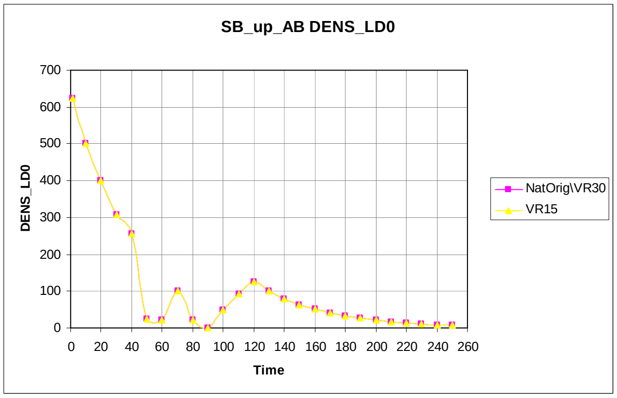
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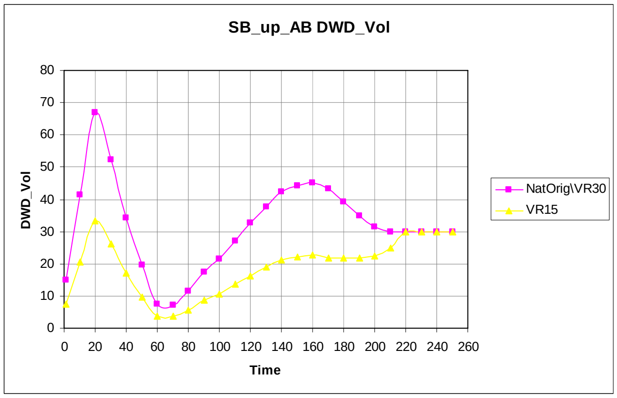
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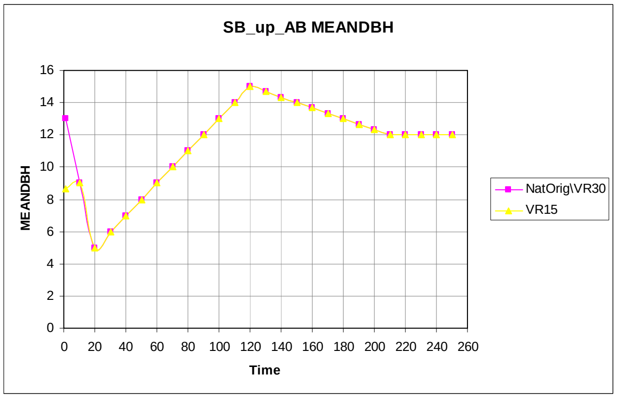
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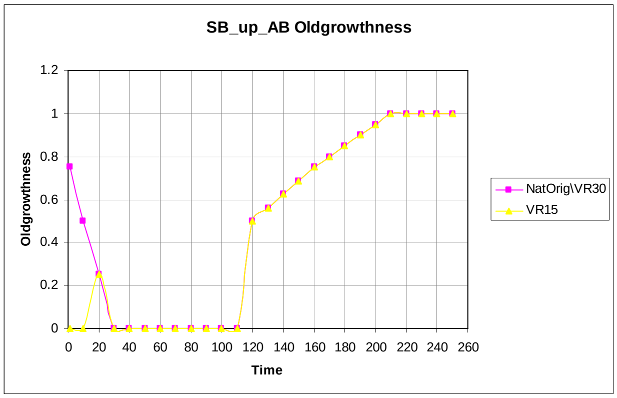
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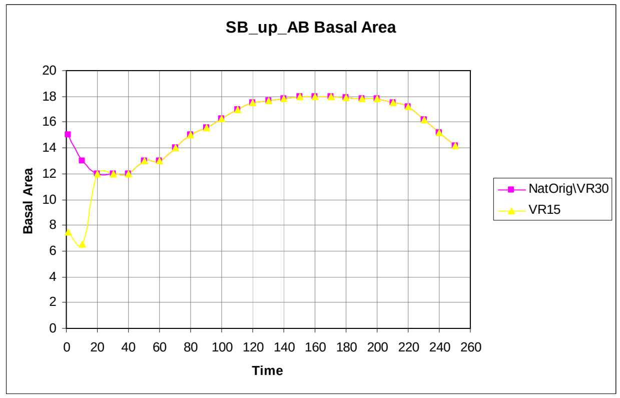
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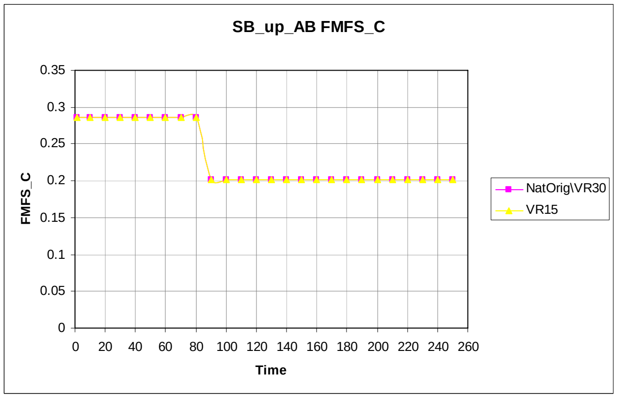
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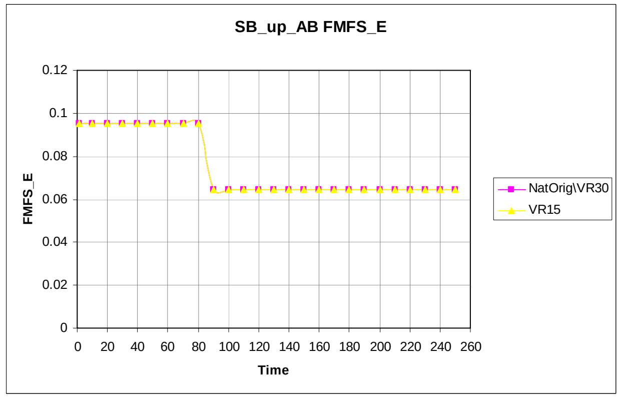
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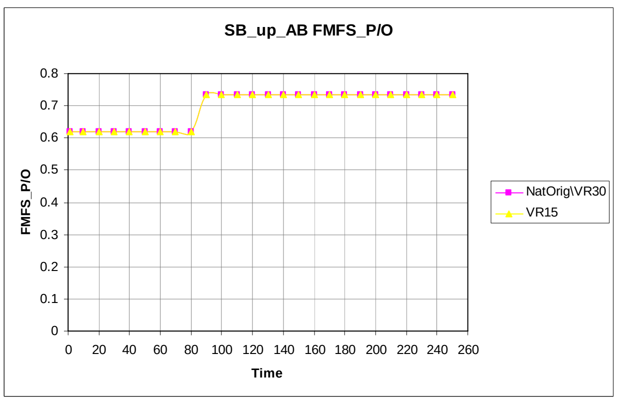
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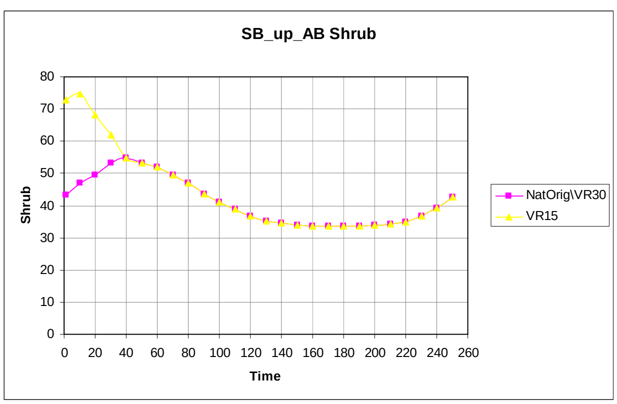
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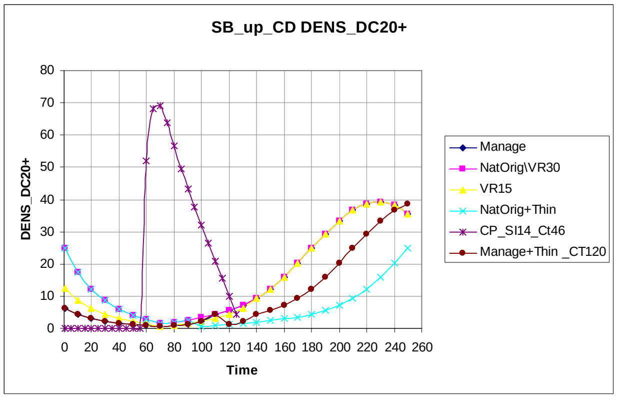
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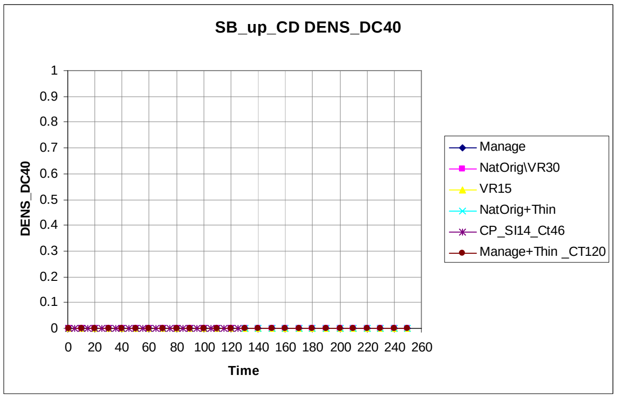
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Time
Manage
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VR15
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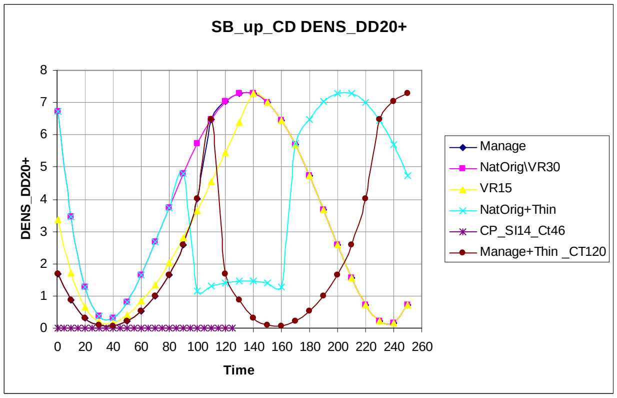
Manage+Thin _CT120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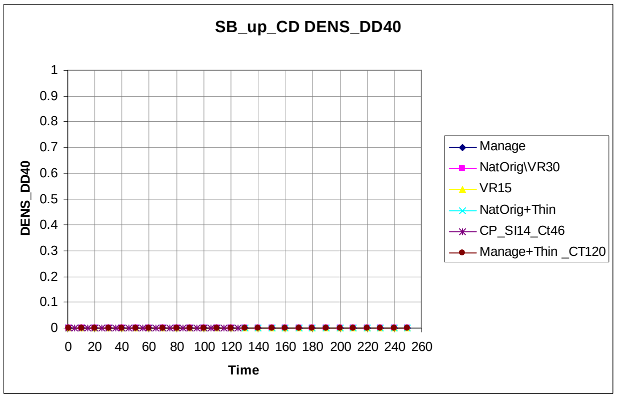
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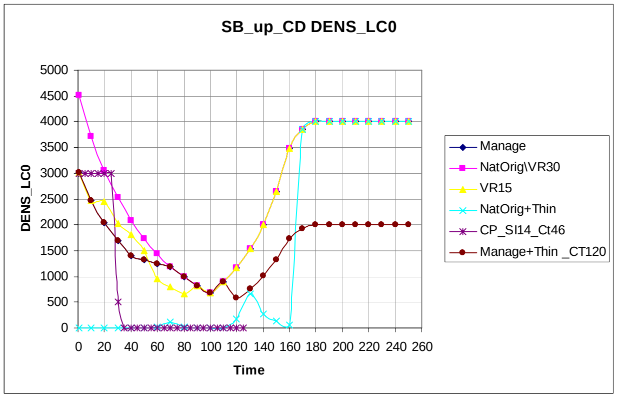
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Time
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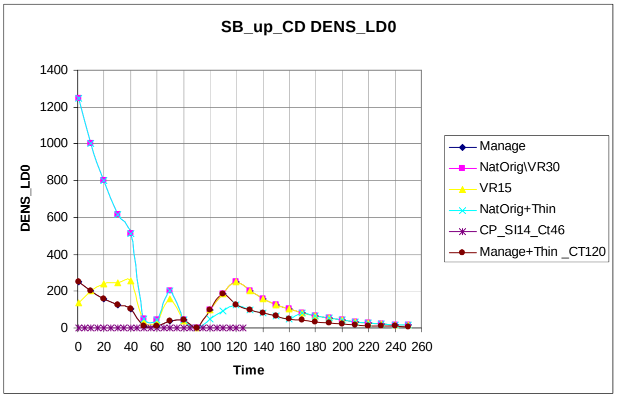
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Time
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VR15
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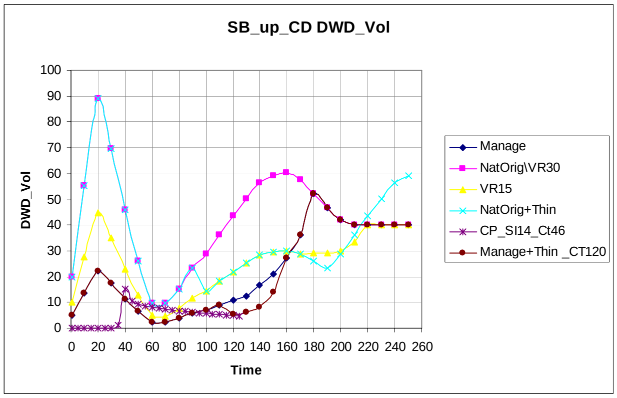
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DWD_Vol
Time
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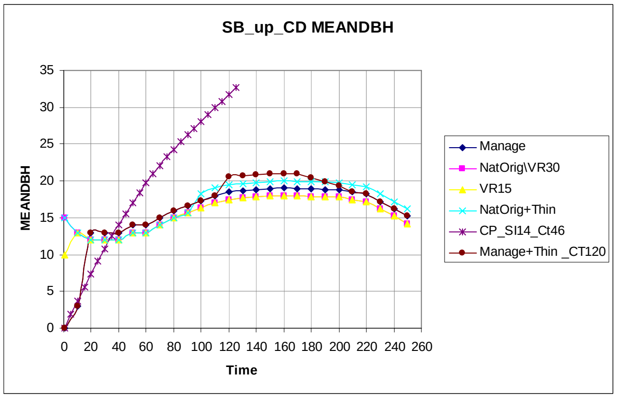
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Time
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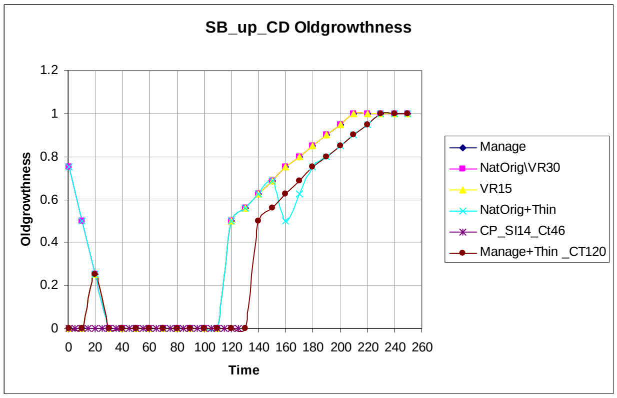
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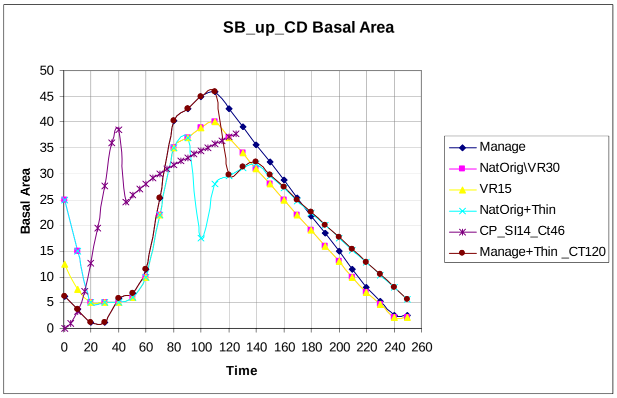
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Time
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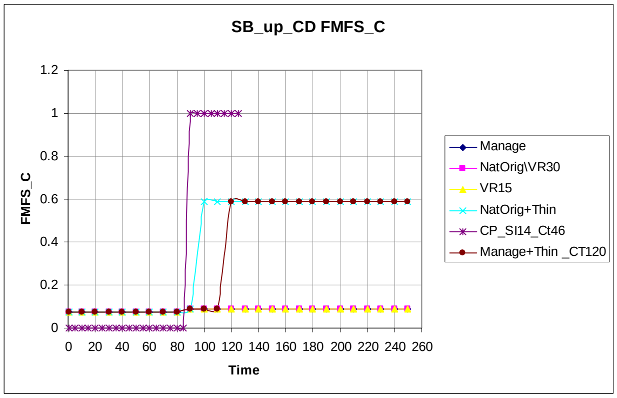
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Time
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VR15
NatOrig+Thin
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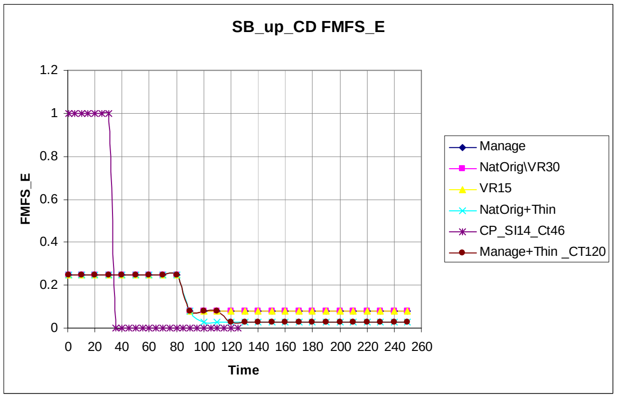
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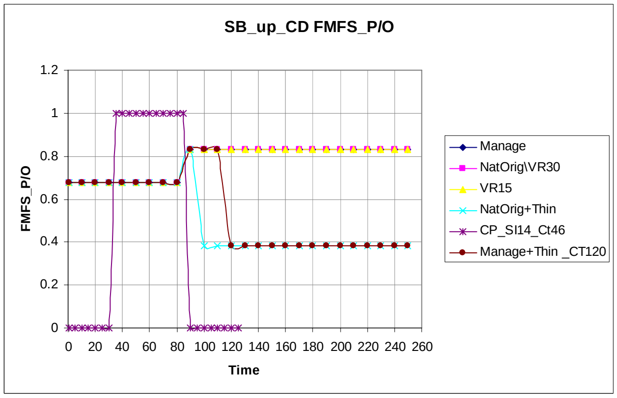
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FMFS_P/O
Time
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NatOrig\VR30
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NatOrig+Thin
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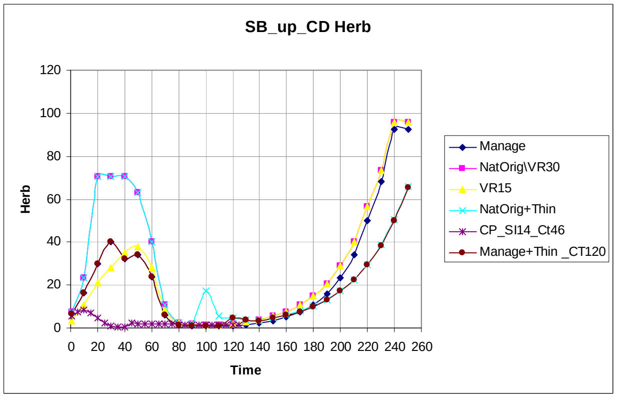
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Herb
Time
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VR15
NatOrig+Thin
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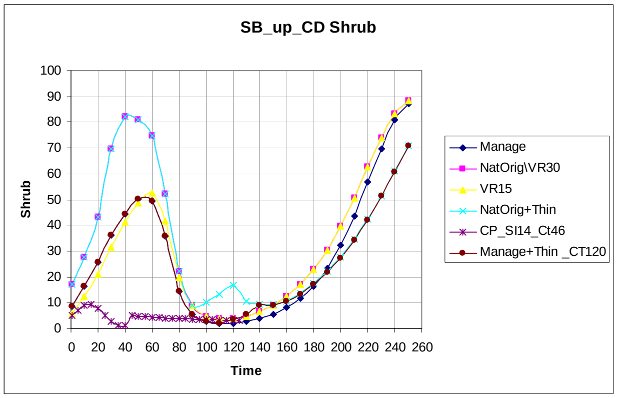
SB_up_CD Shrub
Shrub
Time
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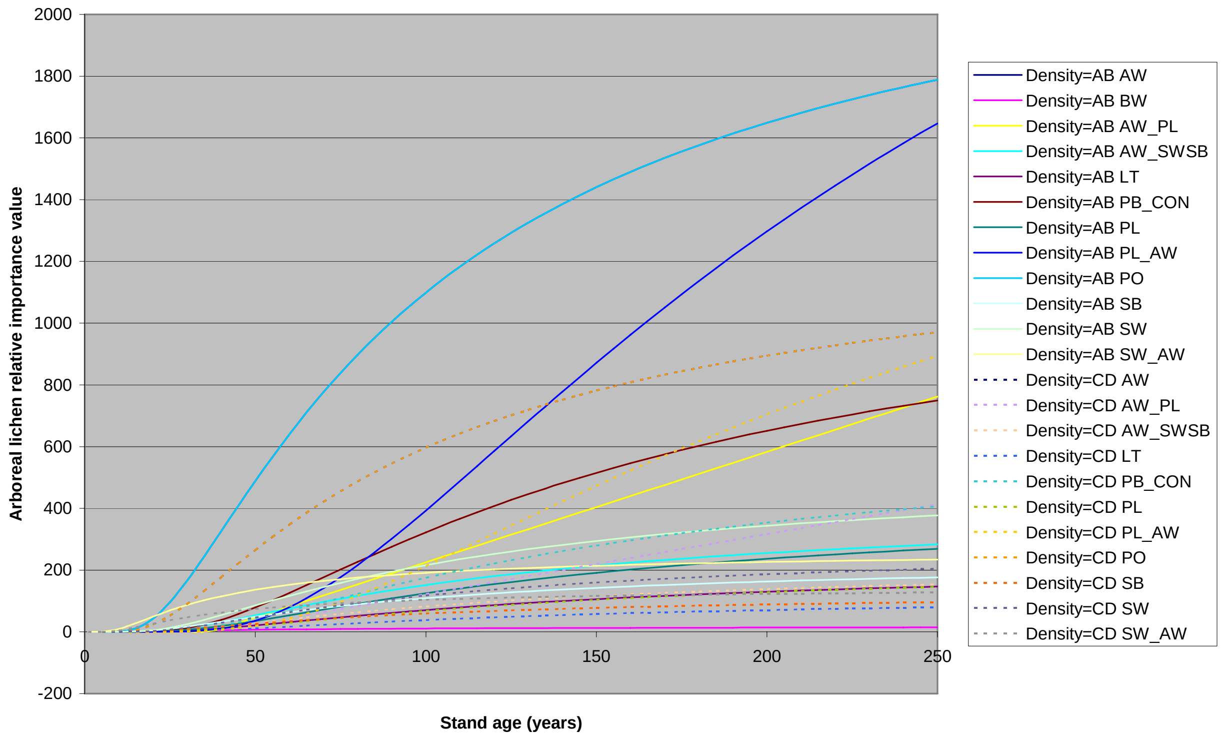
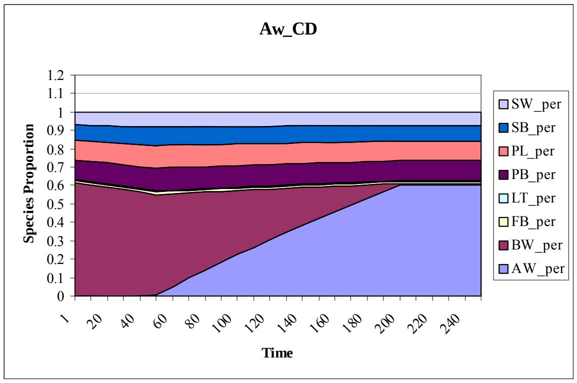
NatOrig+Thin
CP_SI14_Ct46
Manage+Thin _CT120

Arboreal lichen SHE curves



Appendix II Species Composition Curves

MANAGE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Time
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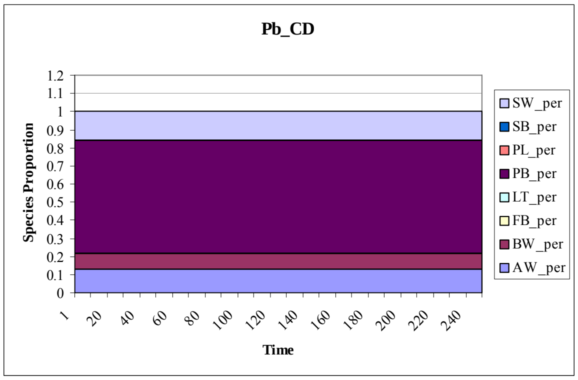
SB_per
PL_per
PB_per
LT_per
FB_per
BW_per
AW_per


Pb_CD
Species Proportion
Time
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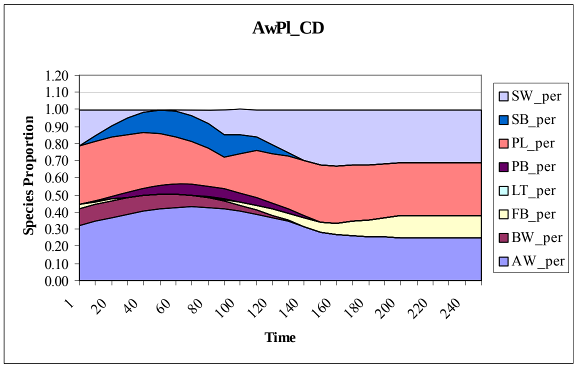
SB_per
PL_per
PB_per
LT_per
FB_per
BW_per
AW_per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Species Proportion
Time
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PL_per
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FB_per
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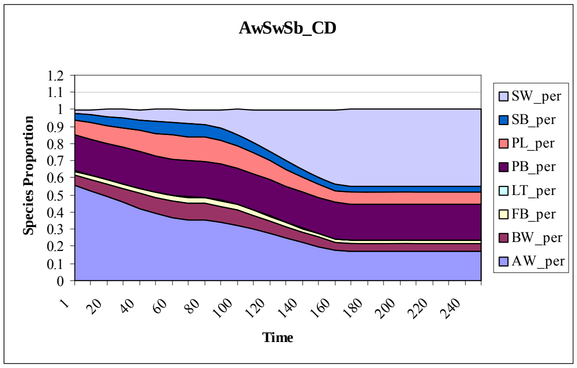
AW_per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Time
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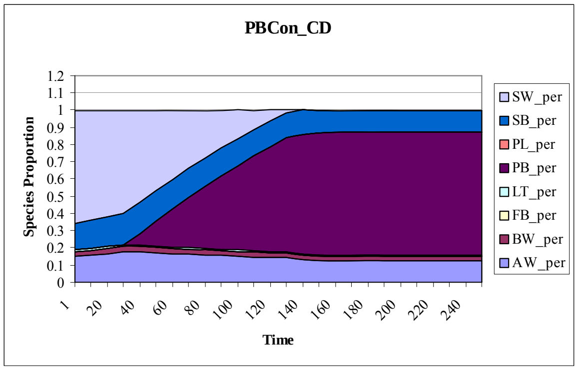
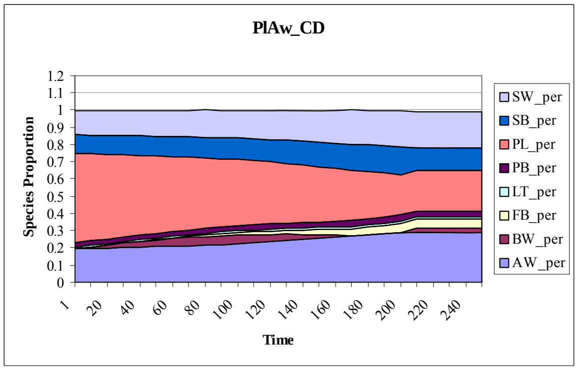
SB_per
PL_per
PB_per
LT_per
FB_per
BW_per
AW_per


PBCon_CD
Species Proportion
Time
SW_per
SB_per
PL_per
PB_per
LT_per
FB_per
BW_per
AW_per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Species Proportion
Time
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SB_per
PL_per
PB_per
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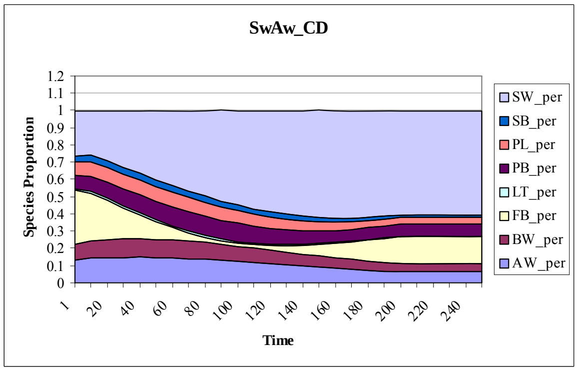
AW_per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Species Proportion
Time
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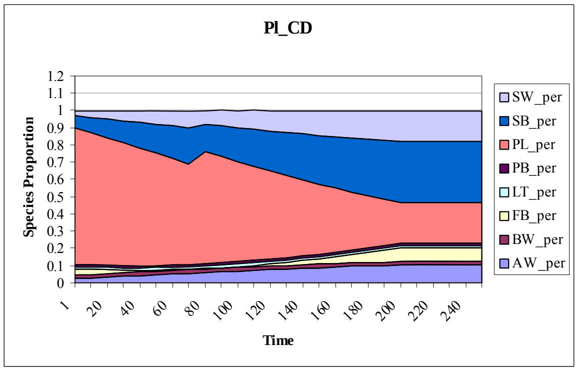
SB_per
PL_per
PB_per
LT_per
FB_per
BW_per
AW_per


Pl_CD
Species Proportion
Time
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PB_per
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FB_per
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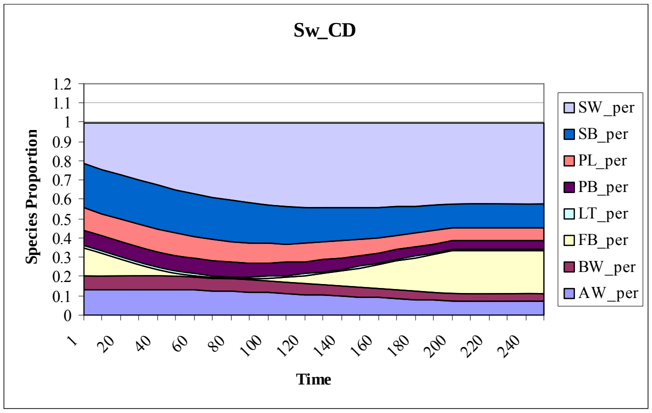
Sw_CD
Species Proportion
Time
1.2
1.1
1
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0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
20
40
60
80
100
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200
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240
SW_per
SB_per
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PB_per
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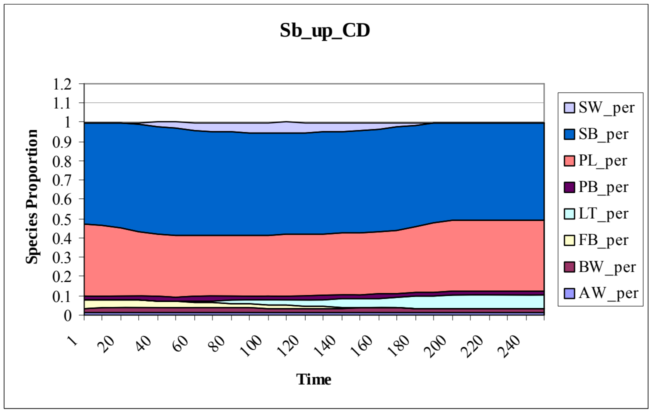
Sb_up_CD
Species Proportion
Time
1.2
1.1
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0.9
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0.6
0.5
0.4
0.3
0.2
0.1
0
1
20
40
60
80
100
120
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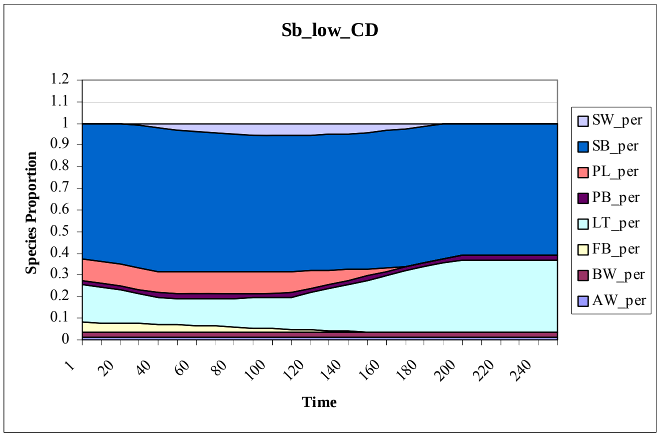
200
220
240
SW_per
SB_per
PL_per
PB_per
LT_per
FB_per
BW_per
AW_per


Sb_low_CD
Species Proportion
Time
1.2
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1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
20
40
60
80
100
120
140
160
180
200
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SW_per
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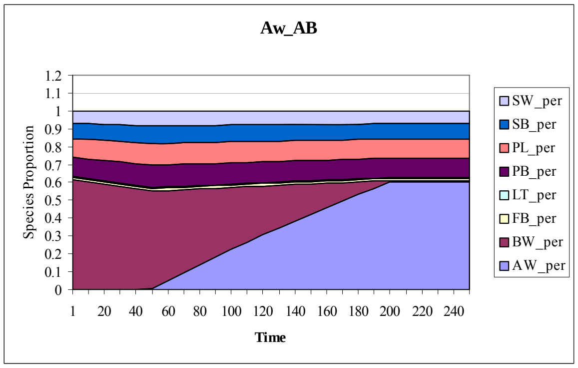
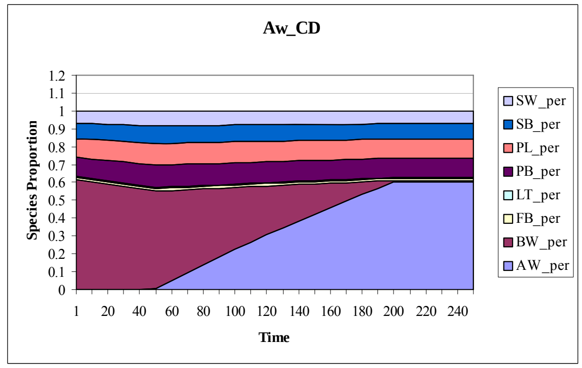
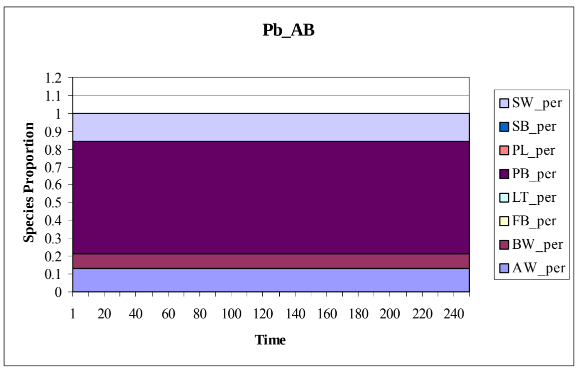
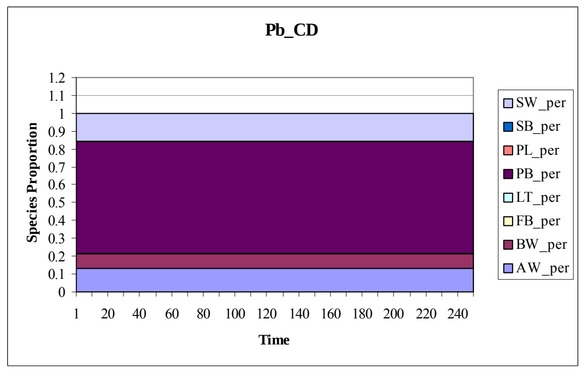
PL_per
PB_per
LT_per
FB_per
BW_per
AW_per

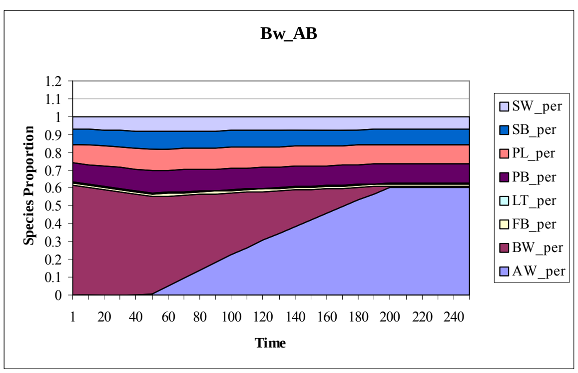
NATURAL ORIGIN / 30% VARIABLE RETENTION

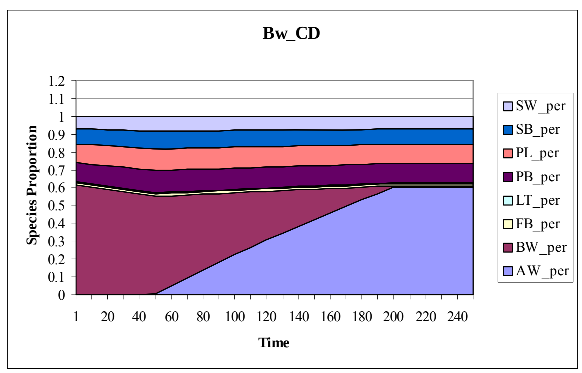


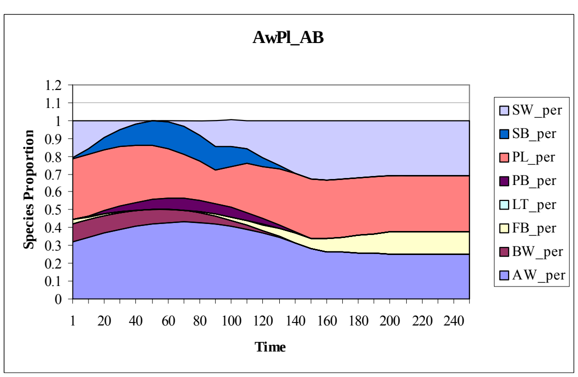


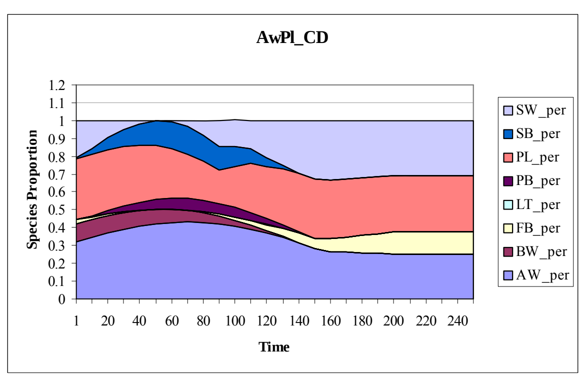


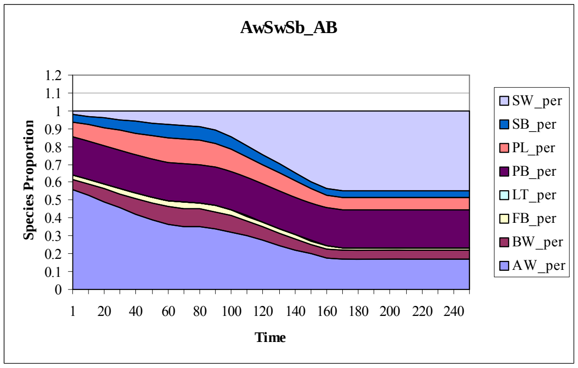








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Species Proportion
Time
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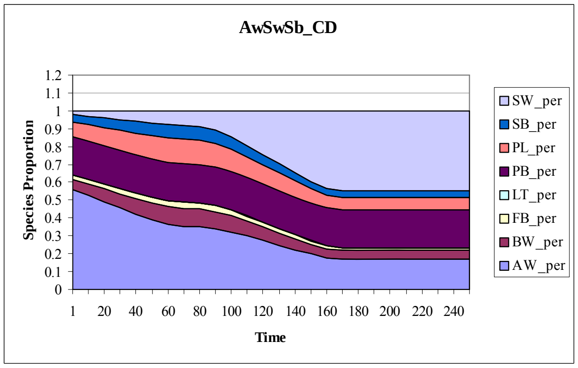
SB_per
PL_per
PB_per
LT_per
FB_per
BW_per
AW_per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Species Proportion
Time
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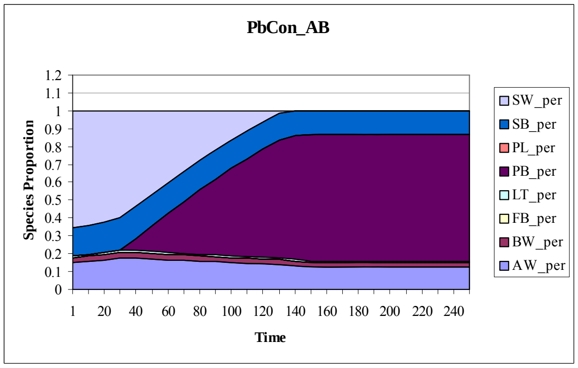
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FB_per
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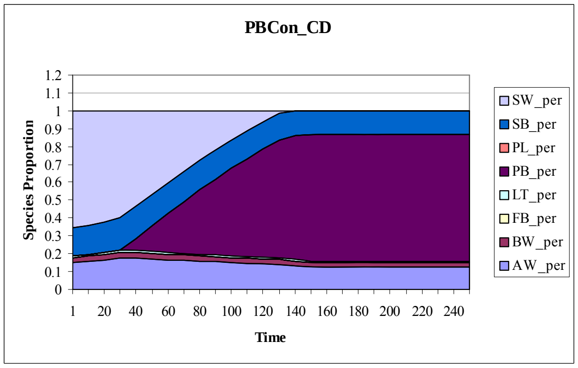
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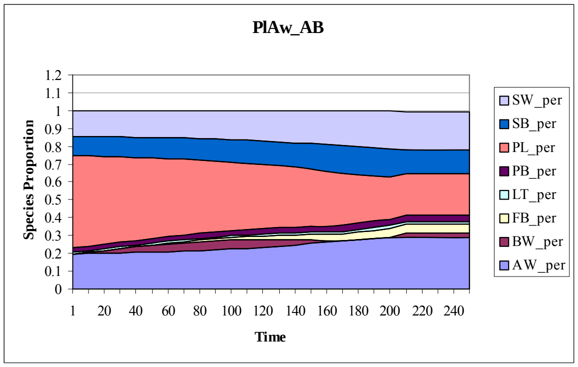
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Species Proportion
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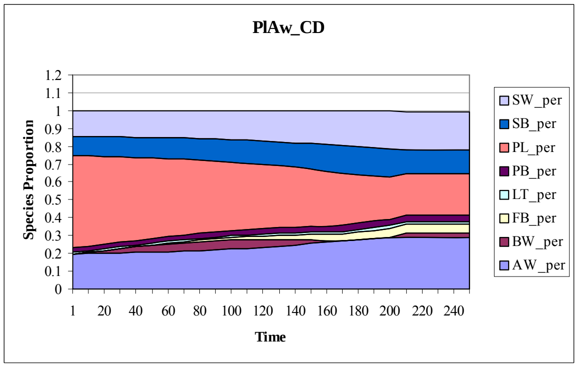
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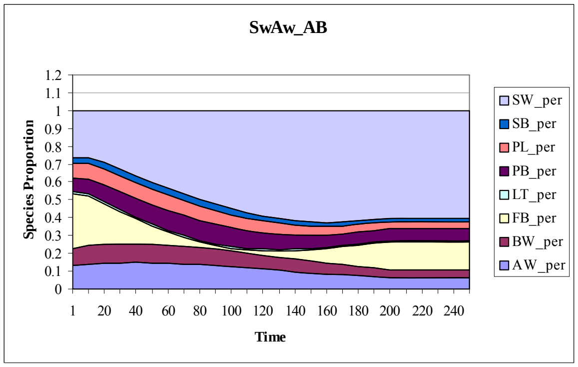
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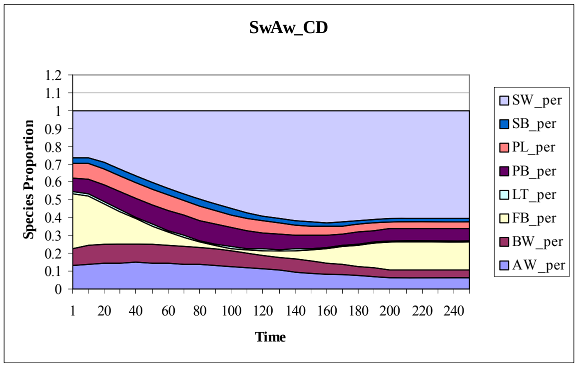
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Time
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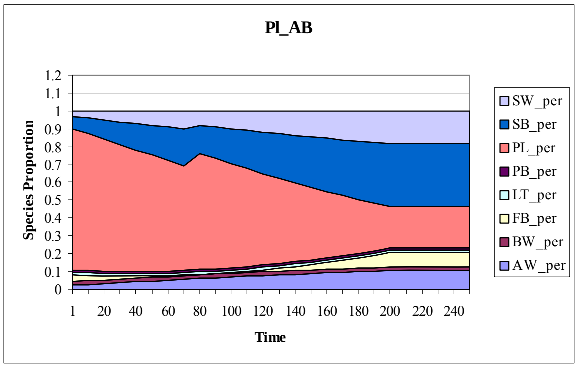
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0
Species Proportion
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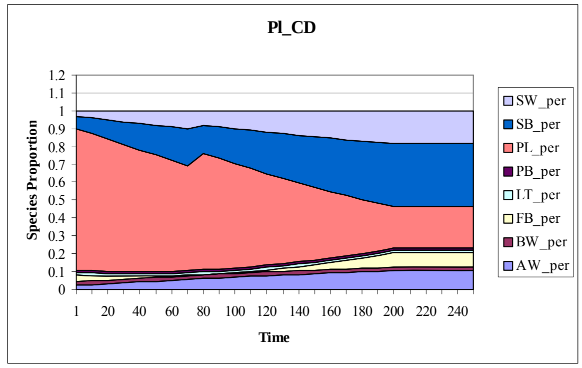
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Species Proportion
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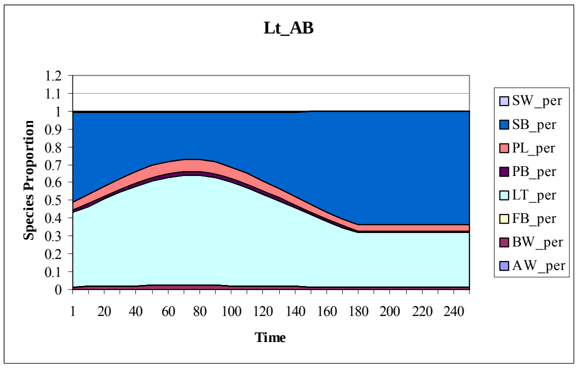
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Species Proportion
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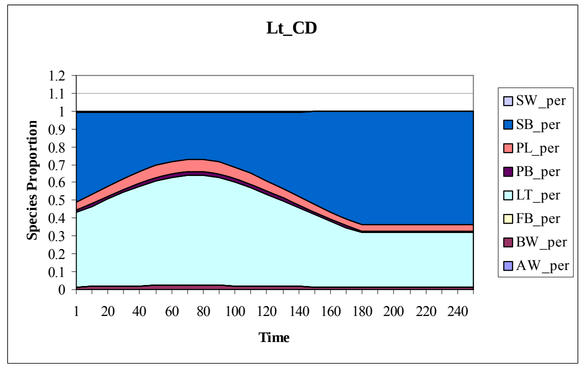
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Species Proportion
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Time
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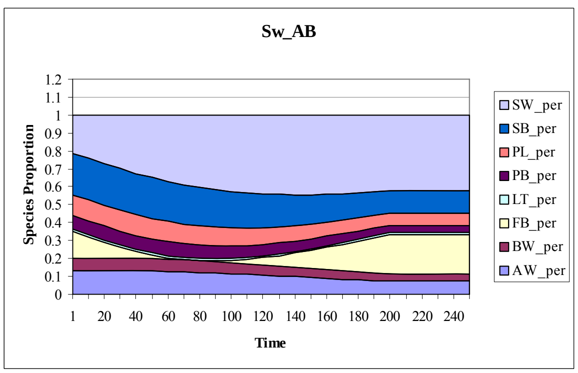
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0.1
0
Species Proportion
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Time
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SB_per
PL_per
PB_per
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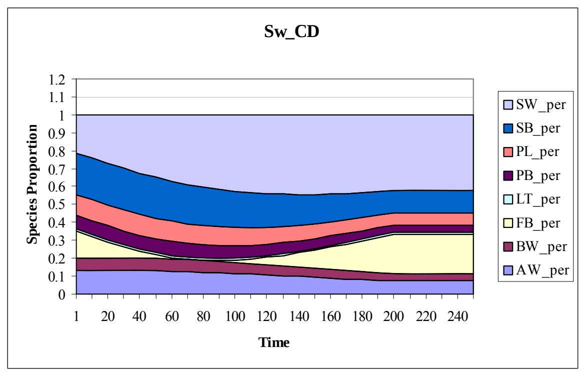
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0.1
0
Species Proportion
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Time
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PL_per
PB_per
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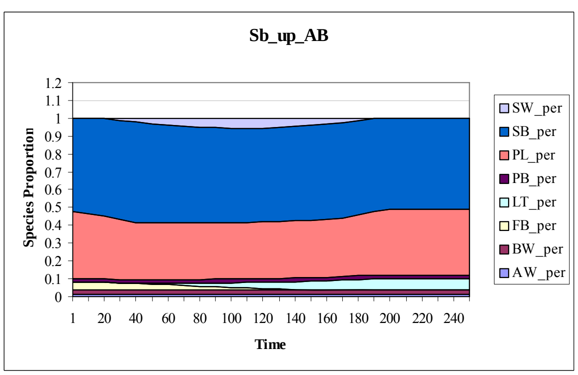
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1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Species Proportion
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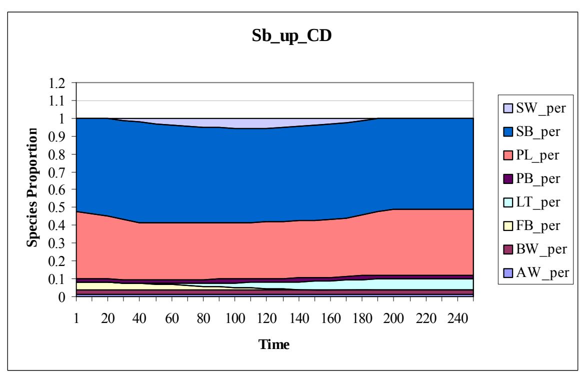
Time
SW_per
SB_per
PL_per
PB_per
LT_per
FB_per
BW_per
AW_per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0.3
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0.1
0
Species Proportion
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Time
SW_per
SB_per
PL_per
PB_per
LT_per
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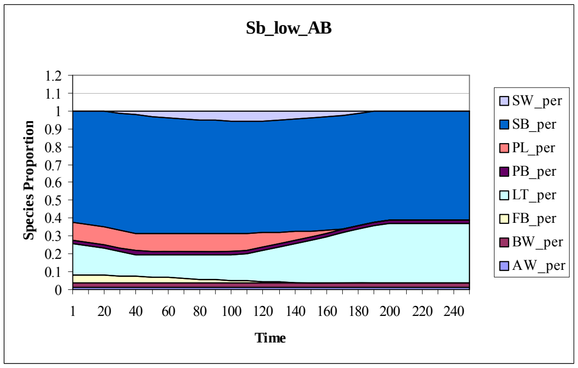
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Species Proportion
Time
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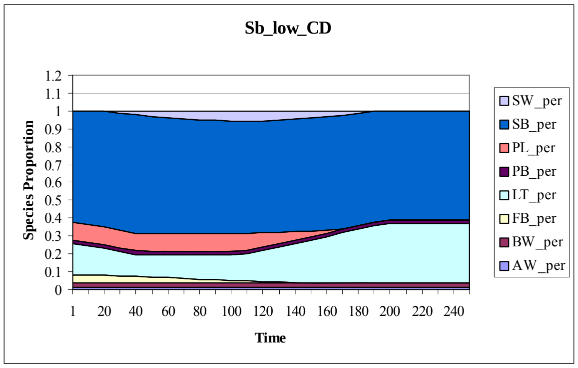
Sb_low_CD
Species Proportion
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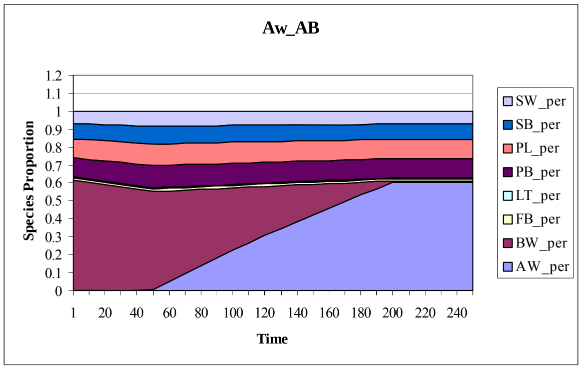
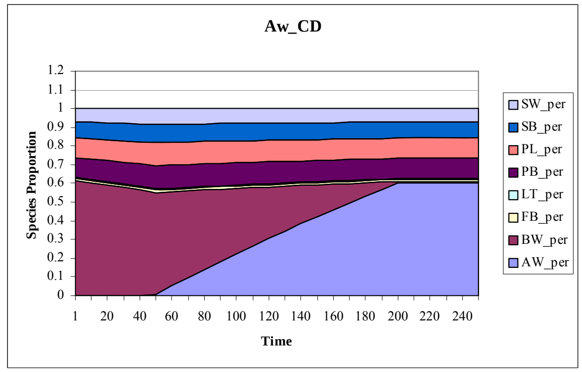
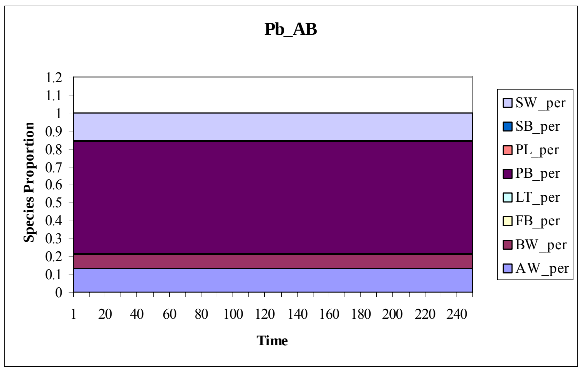
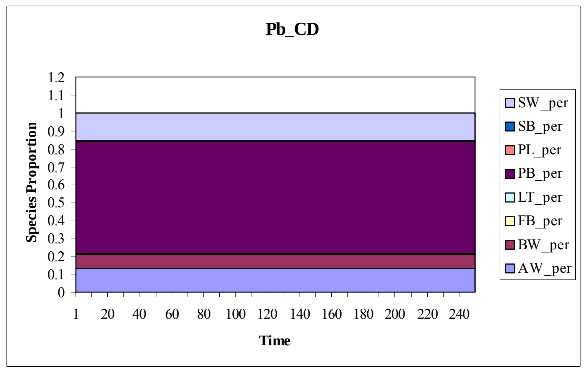
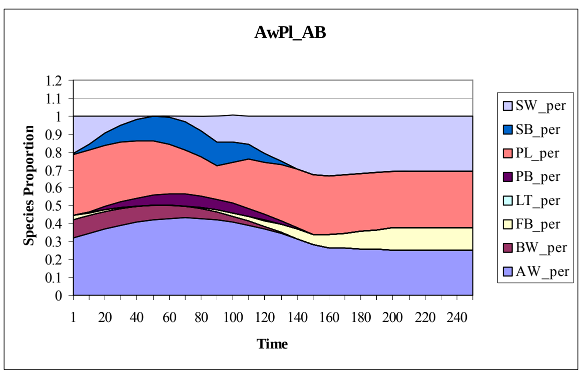
15% VARIABLE RETENTION

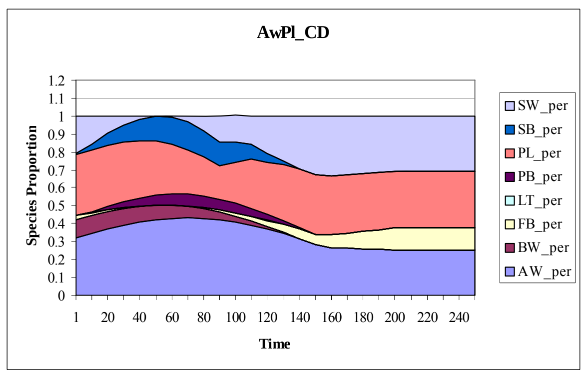


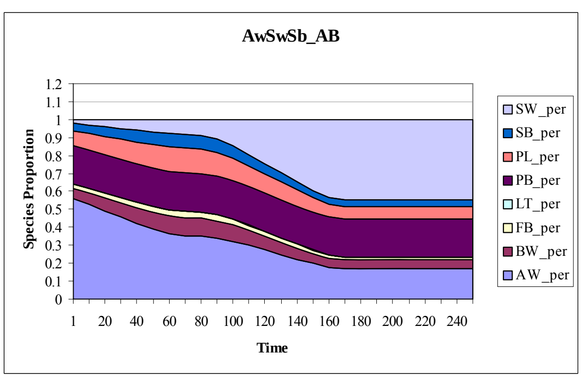


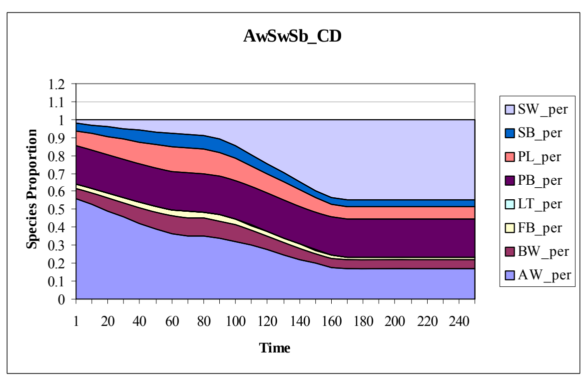


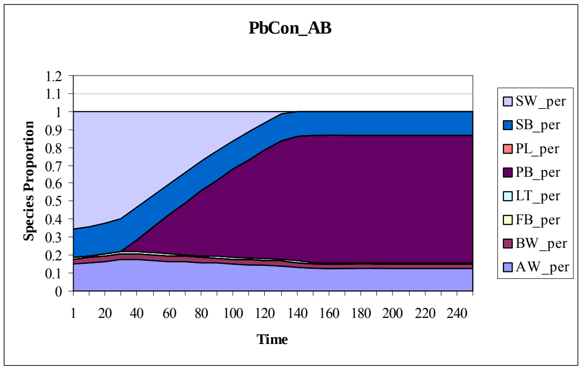











PbCon_AB
Species Proportion
1.2
1.1
1
0.9
0.8
0.7
0.6
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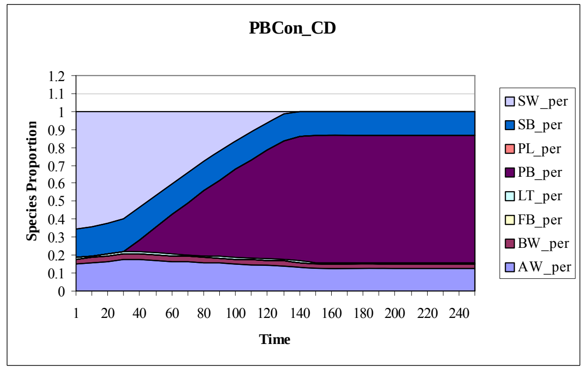
0.4
0.3
0.2
0.1
0
1 20 40 60 80 100 120 140 160 180 200 220 240
Time
SW_per
SB_per
PL_per
PB_per
LT_per
FB_per
BW_per
AW_per


PBCon_CD
Species Proportion
1.2
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0.9
0.8
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0.1
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Time
SW_per
SB_per
PL_per
PB_per
LT_per
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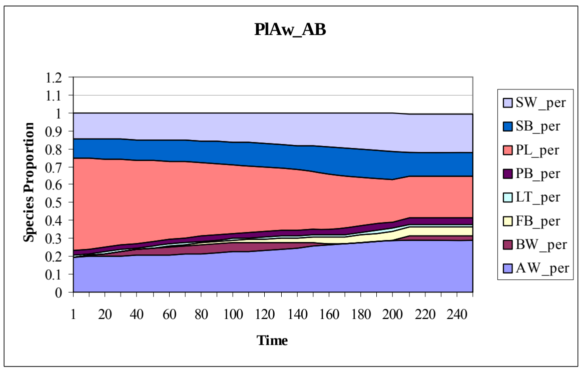
PlAw_AB
Species Proportion
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0.2
0.1
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Time
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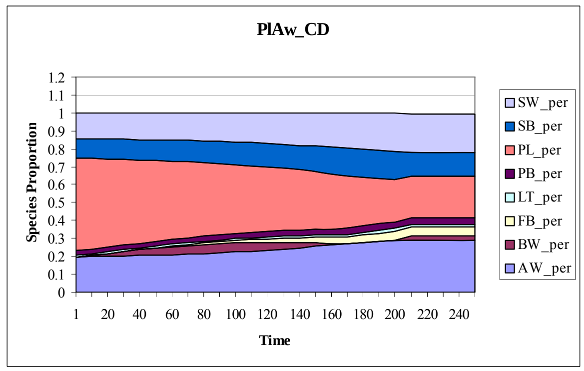
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Species Proportion
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Time
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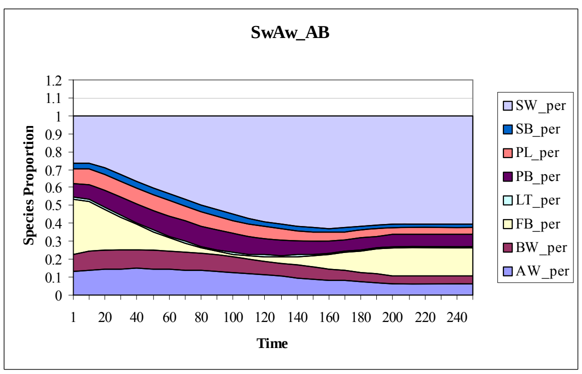
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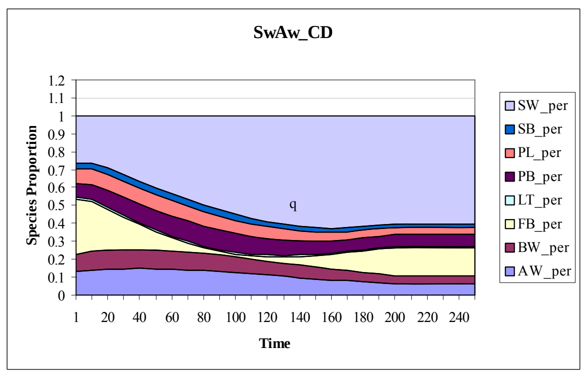
SwAw_CD
Species Proportion
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0.1
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Time
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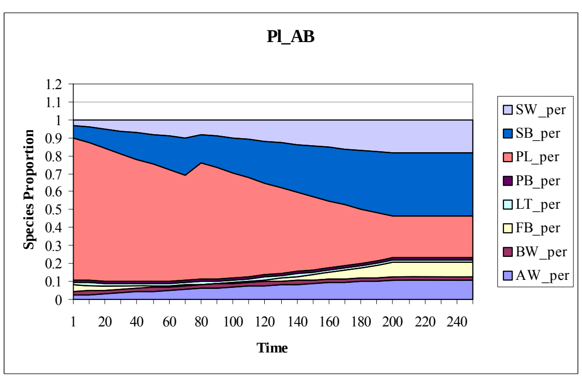
Pl_AB
Species Proportion
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Time
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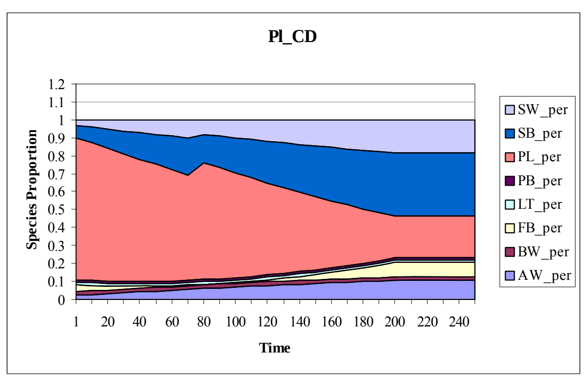
Pl_CD
Species Proportion
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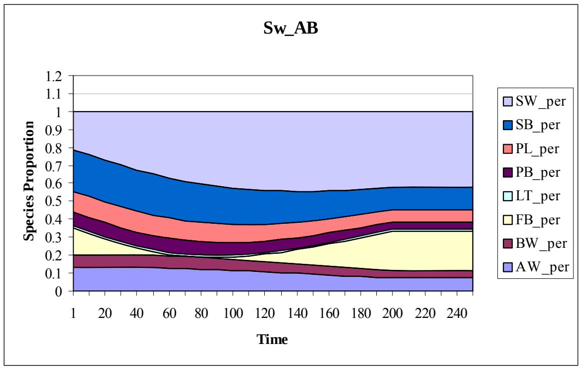
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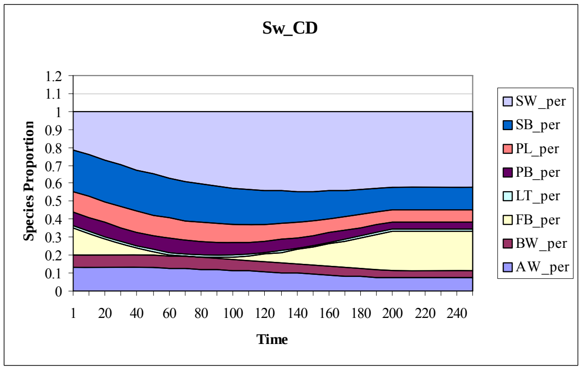
Sw_CD
Species Proportion
Time
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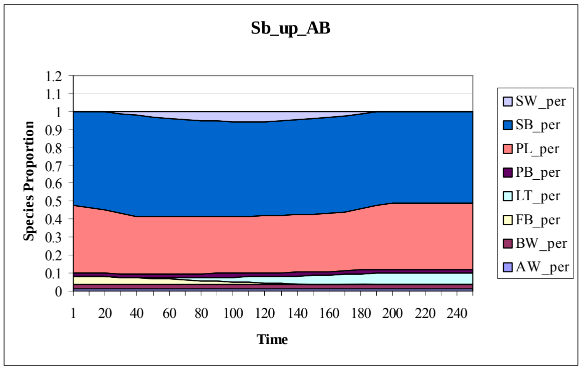
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Species Proportion
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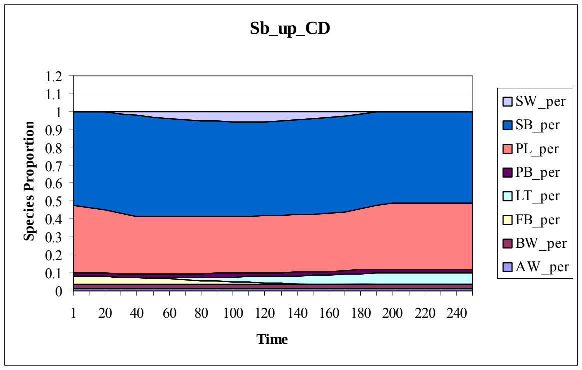
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Species Proportion
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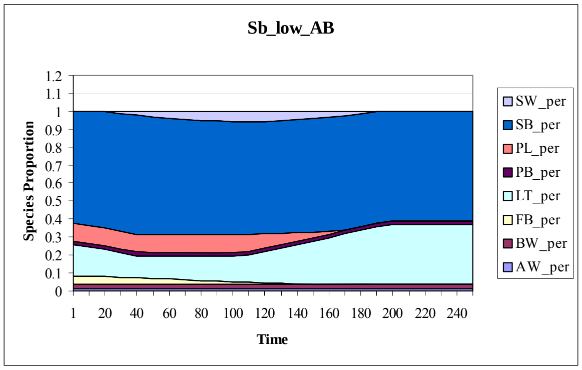
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Species Proportion
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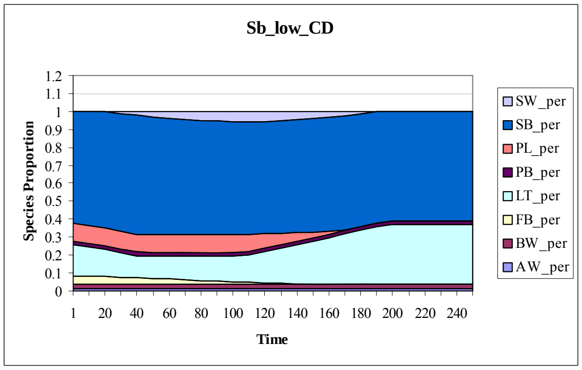
Sb_low_CD
Species Proportion
Time
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PB_per
LT_per
FB_per
BW_per
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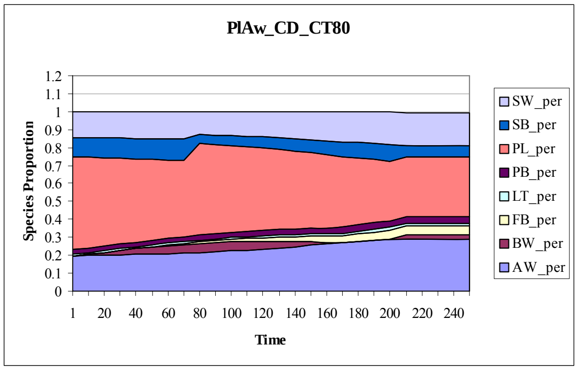
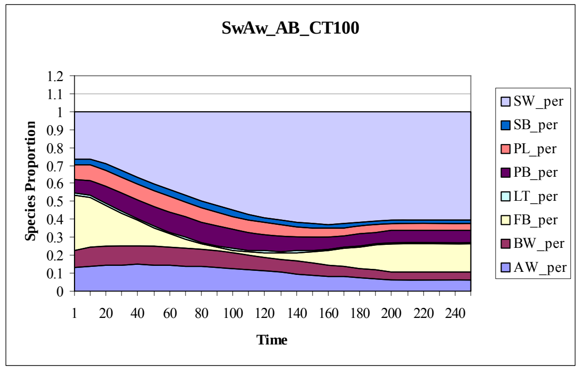
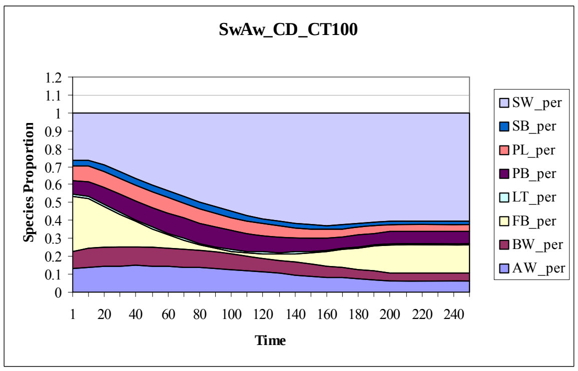
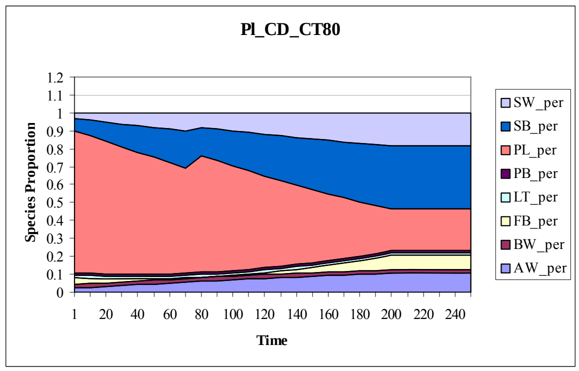
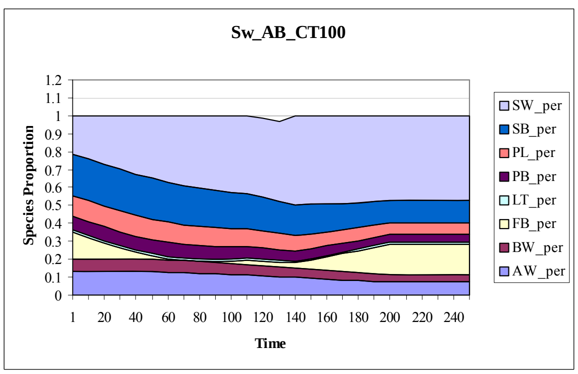
NATURAL ORIGIN + THINNING

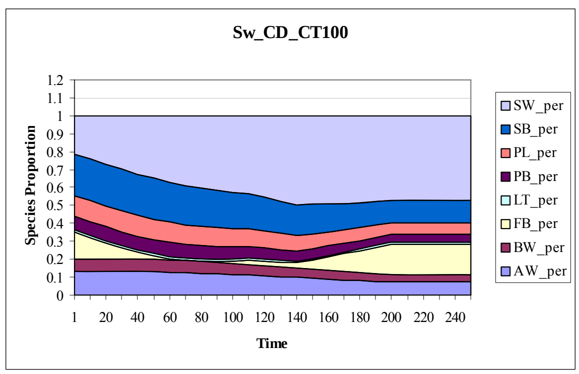


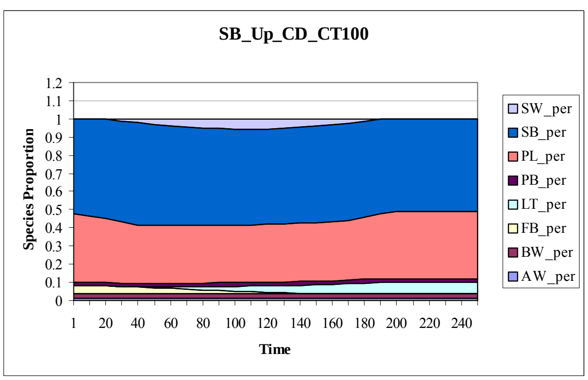




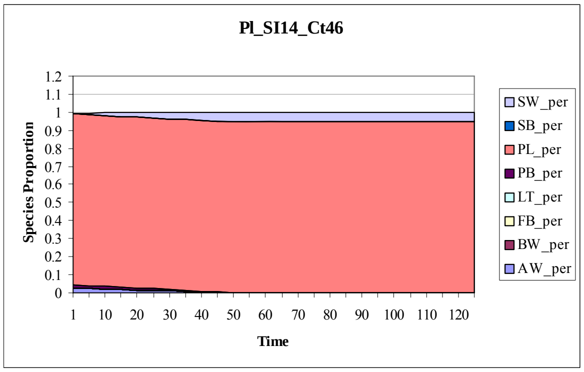








CROP PLAN


Pl_SI14_Ct46
Species Proportion
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PL_per
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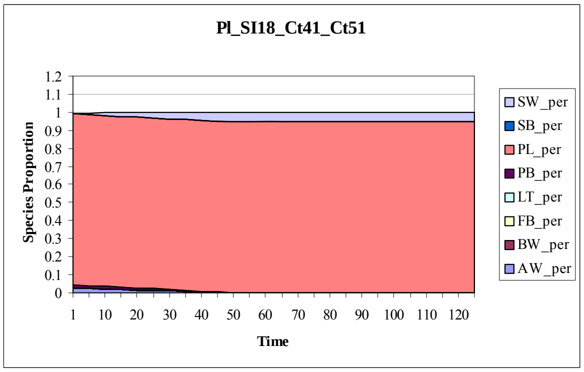
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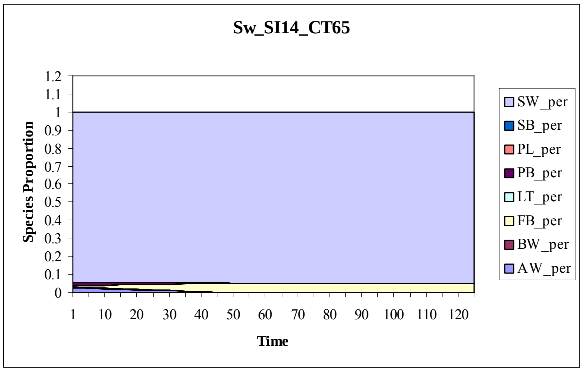
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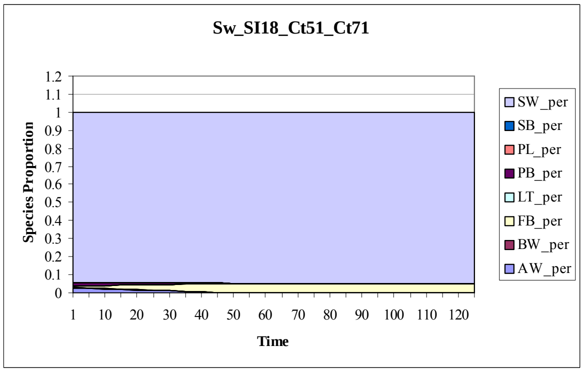
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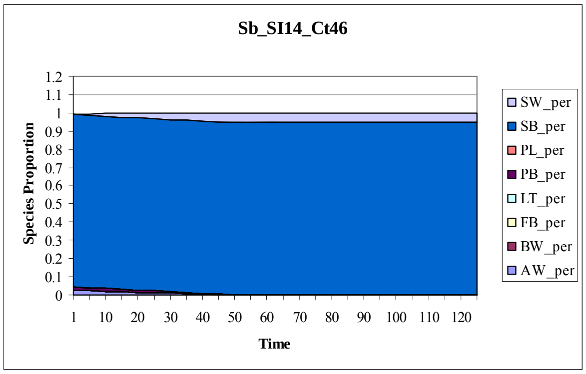
Sb_SI14_Ct46
Species Proportion
Time
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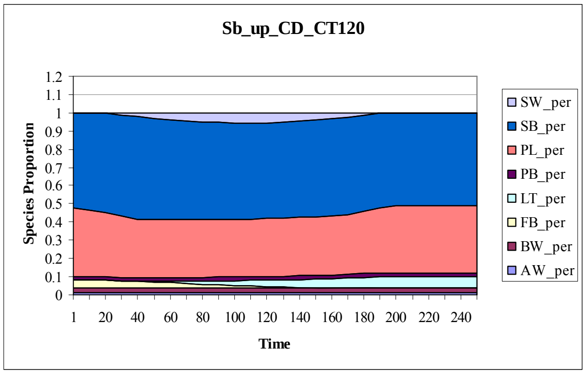
MANAGE + THINNING



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