ANNEX B – SAMSARA2 QUANTITATIVE EVALUATION

I. DATA SET AND SIMULATION METHOD

For the Queige forest, the French National Forest Office provided stand inventories (number of trees per species and dbh class, above 17.5 cm) in 1931, 1949 and 1980, and annual records of tree removals. These data were especially interesting because data providing information on stand stocking and structure on such long periods are scarce (Csillery *et al.*, 2013). However, management interventions were described only by the total stem numbers and volumes marked either as salvage or fresh wood cuts, for each stand and year, but without information on the sizes of cut trees. Inventories did neither include information on regeneration (saplings and poles) nor spatial distribution of adult trees. All adult trees were measured in 1931 and 1949 but data provide only their distribution by species and dbh class. The 1980 inventory was statistical, based on one sampling plot of 5 acres per ha. We had thus to make complementary hypotheses to generate initial stands and simulate harvests with all the details required by the model.

We generated initial stands in 1931 by creating a list of trees of dbh larger than 17.5 cm corresponding to observed distributions. Tree coordinates were simulated so that stand spatial structure mimicked the spatial pattern of a reference experimental plot. Having no information about saplings in the forest inventories, we hypothesized that they were in balance with the adult stands. At the beginning of a simulation, the regeneration sub-model was run during 100 annual iterations without any evolution of the adult stand. The processes of fecundity, seedling survival and sapling growth produced progressively seedling and saplings in all size classes with a spatial distribution in agreement with the irradiance map calculated under adult canopy. Saplings passing the adult recruitment size were simply eliminated during this phase. After about 100 years, the number of seedlings and saplings stabilised and we considered this preliminary phase as finished. The full simulation process, including adult stand evolution was then launched.

We used the “NV Thinner algorithm” described in (Lafond *et al.*, 2012) to select individual trees to harvest, in agreement with the total number and total volume of harvested trees reported in the historical records and the predicted diameter distribution before harvest. (Lafond *et al.*, 2012) have demonstrated that tree selection is efficiently constrained by these three conditions and that the algorithm simulates consistent harvesting diameter distributions.

A command program was developed on the Capsis software platform (Coligny (de) *et al.*, 2003; Dufour-Kowalski *et al.*, 2012) to run automatically the simulations. We ran all simulations with demographic parameters set to their mean estimated value. Parameters were then identical for every stands and uncertainties were not taken into account. 100 replications were done for each stand, in order to take into account the stochasticity of different processes in the model (mortality, seedling survival, individual effects in allometries and growth).

II. GLOBAL STAND CHARACTERISTICS COMPARISON

Indices used for the comparison

We based Samsara2's quantitative evaluation on ten variables supplying complementary information on stands' characteristics:

- Stand volume increment on the simulation period (1931-1980) (Yield, m^3/ha/year)
- Stand stocking in 1980, encompassing stem density (N, t/ha),basal area (m²/ha) and volume (m^3/ha)
- Stand structure in 1980, including quadratic mean diameter (Dg, cm) and the Gini index on individual basal areas (GiniG, no unit), used as a diameter diversity index.
- NB: See part II for more detailed results regarding stand structure, with the comparison of predicted and observed diameter distributions. Regeneration density in 1980, including the total density of poles of diameter class 15cm (Pole15N, t/ha) and detailed densities per species (Pole15N-Spruce and Pole15N-Fir, t/ha).
- Stand composition in 1980, with adult and pole mixing ratios respectively calculated as the proportion of spruce basal area over total basal area (MixR, %) and the proportion of spruce pole density over total pole density in diameter class 15cm (Pole15MixR, %).

Except for pole density and pole mixing ratio, which rely on trees with diameter within [12.5, 17.5[cm, all predicted and observed values have been calculated on trees with diameter d≥ 17.5cm. For all variables, we calculated the **mean difference** (Eq. (B.2)) between predicted and observed values and judged its significance by applying the Student' t test. This test was applied on all predicted (R=100 repetition) and observed (n observations per plot, about 1 observation per ha) values, using the R function *t.test()* (R Core Team, 2012). We also calculated several indices classically used for model evaluation prediction like the **bias** (Eq. (B.3)), **precision** (Eq. (B.4)) and **accuracy** (Eq. (B.5)) of model predictions (Soares *et al.*, 1995; Vanclay and Skovsgaard, 1997; Pretzsch *et al.*, 2002):

$$Eq.(B.1)\ \Delta Y_i(Y\ unit) = Y_{Pred_i} - Y_{Obs_i}$$

$$Eq.(B.2)\ mDiff\ (Y\ unit) = \frac{1}{n}\sum_{i}^{n}\Delta Y_i$$

$$Eq.(B.3)\ Bias\ (\%) = \frac{1}{n}\sum_{i}^{n}\frac{\Delta Y_i}{Y_{Obs_i}} \times 100$$

$$Eq.(B.4)\ Precision\ (\%) = \sqrt{\frac{1}{n}\sum_{i}^{n}(\Delta Y_i - \overline{\Delta Y})^2}$$

$$Eq.(B.5)\ Accuracy\ (\%) = \sqrt{Bias^2 + Precision^2}$$

Stand volume increment – Yield

Plot	Predicted values			Observed values		Comparison				
	Mean	Inf 95%CI	Sup 95%CI	Mean	SE	mDiff	t.test	Bias	Precision	Accuracy
P1	4.14	3.66	4.64	3.20	0.47	0.94	*	29.29	7.74	30.3
P2	3.86	3.36	4.37	2.29	0.50	1.58	***	68.93	11.92	69.95
P4	4.08	3.56	4.54	3.32	0.68	0.76	no	23.04	8.26	24.48
P6	4.70	4.28	5.21	5.16	0.68	-0.46	no	-8.94	4.69	10.1
P7	4.60	4.00	5.17	4.30	0.52	0.31	no	7.13	6.71	9.79
P9	4.12	3.65	4.54	5.00	0.41	-0.87	*	-17.46	5.05	18.18
P11	4.35	3.79	4.86	4.15	0.61	0.19	no	4.65	6.49	7.98
P20	4.18	3.71	4.65	3.86	0.81	0.32	no	8.26	6.41	10.46
P21	3.83	3.25	4.37	3.74	0.96	0.09	no	2.45	6.98	7.4
P22	4.23	3.76	4.70	4.31	0.44	-0.08	no	-1.93	6.51	6.79
P25	4.32	3.86	4.85	3.75	0.62	0.56	no	15.02	7.32	16.71
P26	4.36	3.90	4.92	5.30	0.81	-0.95	no	-17.83	5.13	18.55
P27	4.03	3.55	4.50	5.59	0.45	-1.56	***	-27.89	4.5	28.25
P28	4.82	4.25	5.36	5.31	0.69	-0.49	no	-9.15	5.85	10.86
P29	4.51	4.02	5.05	3.43	0.52	1.08	*	31.63	8.27	32.69
P32	4.22	3.63	4.73	3.68	0.69	0.54	no	14.7	7.92	16.7
P35	3.96	3.40	4.63	3.37	0.81	0.59	no	17.41	8.94	19.57
P36	4.03	3.47	4.53	5.56	1.01	-1.53	no	-27.46	5.11	27.93
P37	4.54	3.94	5.02	3.57	0.55	0.97	*	27.16	8.33	28.41
P38	4.47	3.94	5.02	4.73	0.64	-0.26	no	-5.51	5.78	7.99
P39	4.20	3.71	4.88	3.09	0.80	1.10	no	35.63	9.3	36.82
P40	4.09	3.57	4.58	3.32	0.77	0.76	no	22.96	8.79	24.59
Mean	**4.26**			**4.09**		**0.16**		**8.73**	**7.09**	**21.11**

Table 1: Comparison of predicted and observed volume increments (Yield, m^3/ha/year)

Statistical significance of differences between predicted and observed values (Student' t test) : non-significant (α = 0.05) for p-value ≥ 0.1 (no) and p-value ϵ [0.05, 0.1[(*), significant for p-value ϵ [0.01,0.05[(**) and very significant for p-value <0.01 (***).

Stand stocking

Plot	Predicted values				Observed values		Comparison				
	Mean	SD	Inf 95%CI	Sup 95%CI	Mean	SE	mDiff	t.test	Bias	Precision	Accuracy
P1	194.03	7.81	178.00	208.52	178.89	25.18	15.14	no	8.46	4.37	9.52
P2	178.63	8.20	163.95	194.52	164.21	22.25	14.42	no	8.78	4.99	10.1
P4	183.48	8.13	168.48	198.52	174.00	30.56	9.48	no	5.45	4.67	7.18
P6	169.97	8.24	152.95	185.00	234.29	36.18	-64.32	no	-27.45	3.52	27.67
P7	204.15	8.93	190.00	221.52	208.89	24.12	-4.74	no	-2.27	4.28	4.84
P9	156.02	7.26	143.00	171.00	185.00	21.62	-28.98	no	-15.66	3.93	16.15
P11	191.64	9.31	176.47	210.05	173.33	29.06	18.31	no	10.56	5.37	11.85
P20	187.27	9.07	171.00	201.00	188.18	36.10	-0.91	no	-0.48	4.82	4.84
P21	175.33	9.53	159.00	195.20	125.00	26.76	50.33	*	40.26	7.62	40.97
P22	151.46	7.97	136.00	168.05	133.33	12.29	18.13	no	13.6	5.98	14.86
P25	143.07	9.00	127.47	160.05	113.85	23.92	29.22	no	25.67	7.91	26.86
P26	176.63	7.58	163.00	191.57	197.33	30.60	-20.70	no	-10.49	3.84	11.17
P27	142.30	8.17	124.48	156.05	214.07	27.83	-71.77	**	-33.53	3.81	33.75
P28	154.29	8.23	139.00	168.00	257.14	26.67	-102.85	***	-40	3.2	40.13
P29	194.04	7.55	181.00	208.05	166.32	19.89	27.72	no	16.67	4.54	17.28
P32	175.11	8.04	158.90	190.00	152.73	23.40	22.38	no	14.65	5.26	15.57
P35	150.61	8.58	136.00	168.05	100.00	20.33	50.61	**	50.61	8.58	51.33
P36	174.89	9.63	157.00	193.57	120.00	20.00	54.89	**	45.74	8.03	46.44
P37	163.88	7.56	149.00	179.52	161.25	15.65	2.63	no	1.63	4.69	4.97
P38	142.17	10.89	123.00	166.52	109.33	22.92	32.84	no	30.04	9.96	31.65
P39	172.91	8.32	156.00	186.00	127.69	24.02	45.22	*	35.41	6.51	36
P40	155.73	7.34	141.90	172.00	133.33	24.47	22.40	no	16.8	5.51	17.68
Mean	**169.89**				**164.46**		**5.43**		**8.84**	**5.52**	**21.86**

Table 2: Comparison of predicted and observed stem density (N, t/ha).

Statistical significance of differences between predicted and observed values (Student' t test) : non-significant (α = 0.05) for p-value ≥ 0.1 (no) and p-value ϵ [0.05, 0.1[(*), significant for p-value ϵ [0.01,0.05[(**) and very significant for p-value <0.01 (***).

	Predicted values				Observed values		Comparison				
Plot	Mean	SD	Inf 95%CI	Sup 95%CI	Mean	SE	mDiff	t.test	Bias	Precision	Accuracy
P1	23.33	1.10	21.23	25.25	19.04	2.41	4.29	*	22.55	5.78	23.28
P2	23.76	1.17	21.56	25.97	17.15	2.38	6.61	**	38.54	6.8	39.14
P4	22.01	1.23	19.67	23.91	18.63	3.28	3.38	no	18.17	6.58	19.32
P6	20.84	1.08	18.74	22.79	24.14	3.47	-3.30	no	-13.69	4.47	14.4
P7	25.07	1.33	22.36	27.71	23.74	2.60	1.33	no	5.6	5.6	7.92
P9	18.70	1.13	16.59	20.59	22.55	1.95	-3.85	*	-17.05	5.01	17.77
P11	23.55	1.20	21.11	25.52	22.18	2.88	1.37	no	6.2	5.43	8.24
P20	24.30	1.10	22.19	26.43	22.82	4.01	1.48	no	6.5	4.83	8.1
P21	21.76	1.14	19.14	23.87	20.43	4.39	1.33	no	6.51	5.57	8.57
P22	21.76	1.24	19.76	23.83	21.59	1.98	0.17	no	0.8	5.74	5.8
P25	16.79	1.25	14.70	19.19	13.39	3.00	3.40	no	25.36	9.35	27.03
P26	22.54	1.18	20.32	25.09	26.39	3.87	-3.85	no	-14.58	4.48	15.25
P27	19.36	1.09	17.13	21.27	27.04	2.25	-7.68	***	-28.4	4.05	28.69
P28	28.75	1.38	26.47	31.10	33.00	3.36	-4.25	no	-12.87	4.17	13.53
P29	26.55	1.24	24.45	29.07	21.00	2.52	5.55	**	26.44	5.89	27.09
P32	23.64	1.30	21.06	25.93	21.38	3.25	2.26	no	10.56	6.06	12.18
P35	22.07	1.27	19.77	24.89	18.34	3.65	3.73	no	20.35	6.92	21.49
P36	18.50	1.27	15.99	20.58	23.50	4.41	-5.00	no	-21.28	5.39	21.95
P37	26.41	1.28	23.98	28.34	22.24	2.46	4.17	no	18.77	5.74	19.63
P38	13.46	1.27	10.81	15.89	13.49	2.99	-0.03	no	-0.2	9.4	9.4
P39	24.22	1.24	22.20	27.12	18.45	3.73	5.77	no	31.3	6.72	32.01
P40	23.32	1.25	21.19	25.56	19.19	3.57	4.13	no	21.51	6.53	22.48
Mean	**22.30**				**21.35**		**0.96**		**6.87**	**5.93**	**18.33**

Table 3: Comparison of predicted and observed basal areas (G, m²/ha).

Statistical significance of differences between predicted and observed values (Student' t test) : non-significant ($\alpha = 0.05$) for p-value ≥ 0.1 (no) and p-value ϵ [0.05, 0.1[(*), significant for p-value ϵ [0.01,0.05[(**) and very significant for p-value <0.01 (***).

	Predicted values				Observed values		Comparison				
Plot	Mean	SD	Inf 95%CI	Sup 95%CI	Mean	SE	mDiff	t.test	Bias	Precision	Accuracy
P1	234.29	12.20	210.95	258.09	184.00	23.08	50.29	**	27.33	6.63	28.12
P2	244.68	13.45	219.77	269.51	165.89	24.36	78.79	***	47.5	8.11	48.19
P4	221.29	13.50	194.96	243.93	181.40	33.22	39.89	no	21.99	7.44	23.21
P6	208.06	11.95	186.50	231.88	230.57	33.14	-22.51	no	-9.76	5.18	11.05
P7	250.10	14.30	219.61	277.51	231.78	25.61	18.32	no	7.91	6.17	10.03
P9	186.53	12.31	163.69	207.45	225.83	19.96	-39.30	*	-17.4	5.45	18.23
P11	236.47	13.09	209.47	262.00	221.33	29.83	15.14	no	6.84	5.91	9.04
P20	247.59	12.20	224.80	270.28	226.18	39.85	21.41	no	9.46	5.4	10.89
P21	223.01	12.80	194.60	248.41	216.50	46.80	6.52	no	3.01	5.91	6.63
P22	223.85	13.74	201.28	246.84	226.13	21.41	-2.28	no	-1.01	6.08	6.16
P25	166.96	13.52	144.30	193.64	133.92	30.26	33.04	no	24.67	10.1	26.66
P26	225.98	13.29	203.95	253.52	268.13	39.67	-42.15	no	-15.72	4.96	16.48
P27	198.11	12.21	174.95	221.77	274.37	21.88	-76.26	***	-27.79	4.45	28.14
P28	305.44	15.36	277.49	332.58	328.29	33.87	-22.85	no	-6.96	4.68	8.39
P29	269.85	13.90	245.69	296.82	211.26	25.71	58.59	**	27.73	6.58	28.5
P32	242.13	14.35	212.22	267.09	217.27	34.04	24.86	no	11.44	6.6	13.21
P35	231.28	14.70	204.40	263.86	197.50	39.62	33.78	no	17.1	7.45	18.65
P36	184.39	14.13	158.23	209.36	254.80	49.46	-70.41	no	-27.63	5.55	28.18
P37	276.76	14.38	248.50	300.18	228.00	26.92	48.76	*	21.38	6.31	22.29
P38	129.43	13.59	101.25	156.44	136.80	31.29	-7.37	no	-5.39	9.94	11.31
P39	250.79	14.08	228.15	284.77	192.31	39.39	58.48	no	30.41	7.32	31.28
P40	243.64	14.44	219.15	267.82	199.33	37.57	44.31	no	22.23	7.24	23.38
Mean	**227.30**				**215.98**		**11.32**		**7.61**	**6.52**	**19.46**

Table 4: Comparison of predicted and observed volumes (V, m^3/ha).

Statistical significance of differences between predicted and observed values (Student' t test) : non-significant ($\alpha = 0.05$) for p-value ≥ 0.1 (no) and p-value ϵ [0.05, 0.1[(*), significant for p-value ϵ [0.01,0.05[(**) and very significant for p-value <0.01 (***).

Stand structure

	Predicted values				Observed values		Comparison				
Plot	Mean	SD	Inf 95%CI	Sup 95%CI	Mean	SE	mDiff	t.test	Bias	Precision	Accuracy
P1	39.13	0.80	37.41	40.36	36.83	1.51	2.30	no	6.24	2.18	6.61
P2	41.16	0.88	39.23	42.90	36.53	1.40	4.62	***	12.66	2.4	12.89
P4	39.08	0.81	37.44	40.54	36.86	2.88	2.22	no	6.02	2.19	6.41
P6	39.51	0.81	38.03	41.00	36.23	1.00	3.29	**	9.08	2.23	9.35
P7	39.54	0.73	38.36	40.96	38.08	1.17	1.46	no	3.83	1.91	4.28
P9	39.07	0.96	37.23	40.76	39.41	1.96	-0.34	no	-0.87	2.44	2.59
P11	39.56	0.78	38.18	41.11	40.29	2.43	-0.73	no	-1.81	1.92	2.64
P20	40.66	0.79	39.07	42.13	39.32	1.04	1.34	no	3.41	2.01	3.96
P21	39.77	0.97	37.97	41.77	45.59	2.10	-5.82	**	-12.77	2.12	12.94
P22	42.78	0.86	41.16	44.33	45.30	1.43	-2.52	*	-5.56	1.89	5.87
P25	38.65	1.13	36.66	40.65	38.73	2.09	-0.08	no	-0.2	2.93	2.94
P26	40.31	0.88	38.80	41.88	41.26	1.50	-0.95	no	-2.29	2.14	3.13
P27	41.63	1.05	40.01	43.73	40.14	1.43	1.49	no	3.71	2.61	4.54
P28	48.73	0.93	46.90	50.45	40.42	0.99	8.31	***	20.55	2.29	20.68
P29	41.74	0.70	40.49	43.15	40.11	1.08	1.63	no	4.06	1.76	4.43
P32	41.46	0.90	39.66	43.40	42.27	1.61	-0.81	no	-1.93	2.12	2.87
P35	43.21	1.27	40.71	45.91	48.43	2.71	-5.21	*	-10.76	2.62	11.07
P36	36.70	1.12	34.61	38.65	49.96	2.43	-13.26	***	-26.55	2.25	26.65
P37	45.31	0.86	43.75	46.90	41.87	2.19	3.44	no	8.22	2.05	8.47
P38	34.72	1.33	32.55	37.52	39.57	2.79	-4.85	no	-12.25	3.36	12.7
P39	42.24	0.93	40.41	44.10	42.95	2.08	-0.71	no	-1.65	2.16	2.72
P40	43.67	1.01	41.88	45.53	42.84	2.89	0.83	no	1.93	2.37	3.06
Mean	**40.85**				**41.04**		**-0.20**		**0.14**	**2.27**	**7.76**

Table 5: Comparison of predicted and observed quadratic mean diameters (Dg, cm).

Statistical significance of differences between predicted and observed values (Student' t test) : non-significant (α = 0.05) for p-value ≥ 0.1 (no) and p-value ϵ [0.05, 0.1[(*), significant for p-value ϵ [0.01,0.05[(**) and very significant for p-value <0.01 (***).

	Predicted values				Observed values		Comparison				
Plot	Mean	SD	Inf 95%CI	Sup 95%CI	Mean	SE	mDiff	t.test	Bias	Precision	Accuracy
P1	0.37	0.01	0.34	0.39	0.33	0.02	0.08	***	12.36	4.37	13.11
P2	0.41	0.02	0.38	0.44	0.35	0.02	0.13	***	18	4.35	18.52
P4	0.38	0.01	0.35	0.41	0.36	0.04	0.12	**	5.36	3.88	6.62
P6	0.32	0.01	0.29	0.35	0.30	0.02	0.04	*	7.55	4.52	8.8
P7	0.32	0.01	0.30	0.34	0.30	0.02	0.06	***	5.78	3.48	6.75
P9	0.34	0.01	0.32	0.36	0.36	0.02	0.03	no	-6.24	3.19	7.01
P11	0.34	0.01	0.32	0.37	0.31	0.04	0.09	*	10.57	4.34	11.43
P20	0.38	0.01	0.35	0.40	0.31	0.01	0.12	***	20.7	4.34	21.15
P21	0.43	0.01	0.41	0.46	0.35	0.04	0.13	**	22.75	3.57	23.03
P22	0.33	0.02	0.30	0.36	0.29	0.03	0.08	***	13.08	5.71	14.27
P25	0.35	0.01	0.32	0.37	0.39	0.02	0.01	no	-10.85	3.35	11.36
P26	0.31	0.01	0.28	0.33	0.34	0.02	0.02	no	-8.27	4.27	9.31
P27	0.35	0.01	0.32	0.38	0.39	0.02	0.03	no	-9.38	3.67	10.07
P28	0.22	0.02	0.19	0.25	0.27	0.02	-0.03	no	-17.35	5.6	18.23
P29	0.31	0.01	0.29	0.34	0.34	0.02	0.00	no	-10.16	3.97	10.91
P32	0.37	0.01	0.34	0.39	0.30	0.03	0.11	***	21.16	4.07	21.55
P35	0.41	0.02	0.37	0.43	0.35	0.03	0.11	**	17	4.43	17.57
P36	0.43	0.01	0.41	0.45	0.30	0.03	0.18	***	41.7	3.92	41.88
P37	0.32	0.01	0.28	0.34	0.34	0.02	0.07	***	-7.16	4.25	8.33
P38	0.37	0.02	0.33	0.40	0.40	0.03	0.08	*	-7.44	4.16	8.52
P39	0.38	0.01	0.36	0.41	0.40	0.03	0.03	no	-4.38	3.37	5.53
P40	0.37	0.01	0.34	0.39	0.39	0.03	0.12	***	-6.51	3.2	7.25
Mean	**0.36**				**0.34**		**0.07**		**4.92**	**4.09**	**13.69**

Table 6: Comparison of predicted and observed Gini indices, calculated on individual basal areas (GiniG, no unit).

Statistical significance of differences between predicted and observed values (Student' t test) : non-significant (α = 0.05) for p-value ≥ 0.1 (no) and p-value ϵ [0.05, 0.1[(*), significant for p-value ϵ [0.01,0.05[(**) and very significant for p-value <0.01 (***).

Regeneration

	Predicted values				Observed values		Comparison				
Plot	Mean	SD	Inf 95%CI	Sup 95%CI	Mean	SE	mDiff	t.test	Bias	Precision	Accuracy
P1	155.64	17.77	119.00	188.52	17.78	5.34	137.86	***	775.37	99.92	781.78
P2	195.00	16.52	165.00	224.00	12.63	4.11	182.37	***	1443.94	130.83	1449.85
P4	197.81	17.72	170.00	243.05	38.00	21.80	159.81	***	420.55	46.63	423.13
P6	62.73	8.74	48.00	78.52	11.43	7.38	51.30	***	448.82	76.45	455.28
P7	64.86	8.84	48.42	80.00	14.81	3.79	50.05	***	337.95	59.69	343.18
P9	91.66	10.28	70.42	111.52	26.67	11.89	64.99	***	243.68	38.54	246.71
P11	151.48	15.03	122.47	177.00	10.00	4.47	141.48	***	1414.8	150.28	1422.76
P20	180.90	14.42	152.47	207.52	4.55	2.25	176.35	***	3875.82	316.93	3888.76
P21	264.66	21.89	219.38	303.00	11.67	4.58	252.99	***	2167.87	187.54	2175.97
P22	101.18	10.44	81.47	123.05	9.33	3.30	91.85	***	984.46	111.92	990.8
P25	129.05	14.89	105.00	159.10	13.08	4.43	115.97	***	886.62	113.84	893.9
P26	92.92	9.94	74.47	111.00	28.00	8.90	64.92	***	231.86	35.51	234.56
P27	106.43	11.46	84.95	128.00	32.59	10.63	73.84	***	226.57	35.15	229.28
P28	32.55	5.97	22.48	45.00	32.86	8.01	-0.31	no	-0.94	18.16	18.18
P29	66.98	8.97	50.00	86.57	35.79	8.99	31.19	***	87.15	25.06	90.68
P32	130.16	12.93	108.00	158.05	14.55	6.08	115.61	***	794.57	88.85	799.52
P35	174.52	15.52	147.47	202.05	11.25	6.82	163.27	***	1451.29	137.98	1457.83
P36	251.20	19.10	218.00	291.05	12.00	3.27	239.20	***	1993.33	159.18	1999.68
P37	81.17	10.15	64.00	97.05	22.50	7.72	58.67	***	260.76	45.13	264.64
P38	172.46	16.90	139.48	205.05	29.33	11.69	143.13	***	488	57.62	491.39
P39	148.51	15.85	117.43	178.62	29.23	6.65	119.28	***	408.07	54.24	411.66
P40	110.11	11.68	87.90	133.10	38.89	9.49	71.22	***	183.13	30.02	185.57
Mean	**134.64**				**20.77**		**113.87**		**869.26**	**91.79**	**875.23**

Table 7: Comparison of predicted and observed pole density (PoleQty, t/ha).

Statistical significance of differences between predicted and observed values (Student' t test) : non-significant ($\alpha = 0.05$) for p-value ≥ 0.1 (no) and p-value ϵ [0.05, 0.1[(*), significant for p-value ϵ [0.01,0.05[(**) and very significant for p-value <0.01 (***).

	Predicted values				Observed values		Comparison				
Plot	Mean	SD	Inf 95%CI	Sup 95%CI	Mean	SE	mDiff	t.test	Bias	Precision	Accuracy
P1	155.64	17.77	119.00	188.52	17.78	5.34	137.86	***	775.37	99.92	781.78
P2	195.00	16.52	165.00	224.00	12.63	4.11	182.37	***	1443.94	130.83	1449.85
P4	194.57	17.55	165.47	238.67	34.00	21.72	160.57	***	472.26	51.63	475.07
P6	62.37	8.68	48.00	78.52	11.43	7.38	50.94	***	445.67	75.95	452.1
P7	58.98	8.07	42.95	74.52	13.33	3.54	45.65	***	342.46	60.56	347.77
P9	74.02	8.46	59.48	91.52	10.00	5.77	64.02	***	640.2	84.59	645.76
P11	130.80	14.01	101.95	156.00	0.00	0.00	130.80	***	NA	NA	NA
P20	164.96	13.19	138.00	187.52	3.64	1.68	161.32	***	4431.87	362.36	4446.66
P21	235.44	19.85	196.47	270.52	8.33	3.86	227.11	***	2726.41	238.24	2736.8
P22	79.81	8.76	63.90	97.52	5.33	2.36	74.48	***	1397.37	164.44	1407.01
P25	83.66	11.23	65.95	105.00	3.08	2.40	80.58	***	2616.23	364.66	2641.52
P26	73.10	8.82	55.95	91.52	9.33	4.31	63.77	***	683.49	94.48	689.99
P27	84.04	9.74	67.47	102.52	20.00	7.99	64.04	***	320.2	48.72	323.89
P28	20.31	4.01	14.00	28.00	8.57	4.04	11.74	**	136.99	46.78	144.76
P29	53.82	8.19	39.00	73.05	11.58	3.53	42.24	***	364.77	70.74	371.57
P32	123.95	13.04	101.47	150.52	14.55	6.08	109.40	***	751.89	89.64	757.21
P35	149.16	15.12	120.95	176.00	6.25	3.97	142.91	***	2286.56	241.85	2299.31
P36	174.67	14.93	147.95	203.52	4.00	2.67	170.67	***	4266.75	373.17	4283.04
P37	59.39	8.22	43.00	74.05	7.50	3.10	51.89	***	691.87	109.57	700.49
P38	110.18	13.22	83.47	135.10	10.67	7.00	99.51	***	932.61	123.91	940.81
P39	91.64	11.76	70.00	116.05	7.69	3.61	83.95	***	1091.68	152.96	1102.34
P40	72.00	9.51	56.42	93.00	3.33	1.81	68.67	***	2062.16	285.62	2081.85
Mean	**111.25**				**10.14**		**101.11**		**1375.27**	**155.74**	**1384.74**

Table 8: Comparison of predicted and observed pole density (PoleQty, t/ha) for spruce.

Statistical significance of differences between predicted and observed values (Student' t test) : non-significant (α = 0.05) for p-value ≥ 0.1 (no) and p-value ϵ [0.05, 0.1[(*), significant for p-value ϵ [0.01,0.05[(**) and very significant for p-value <0.01 (***).

	Predicted values				Observed values		Comparison				
Plot	Mean	SD	Inf 95%CI	Sup 95%CI	Mean	SE	mDiff	t.test	Bias	Precision	Accuracy
P1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	no	NA	NA	NA
P2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	no	NA	NA	NA
P4	3.24	1.82	0.00	7.00	2.00	2.00	1.24	no	62	90.77	109.92
P6	0.36	0.58	0.00	2.00	0.00	0.00	0.36	***	NA	NA	NA
P7	5.88	2.44	1.48	10.52	0.74	0.74	5.14	***	694.59	329.49	768.78
P9	17.64	4.75	9.48	27.00	16.67	7.72	0.97	no	5.82	28.49	29.08
P11	20.68	4.57	14.00	28.52	10.00	4.47	10.68	*	106.8	45.72	116.17
P20	15.94	4.71	7.00	26.00	0.91	0.91	15.03	***	1651.65	517.04	1730.69
P21	29.22	6.23	18.00	41.00	3.33	2.25	25.89	***	777.48	187.01	799.65
P22	21.37	4.82	13.00	32.00	2.67	1.82	18.70	***	700.37	180.42	723.24
P25	45.39	7.09	33.47	59.52	9.23	3.18	36.16	***	391.77	76.86	399.24
P26	19.82	4.45	10.48	28.52	17.33	6.13	2.49	no	14.37	25.71	29.45
P27	22.39	5.07	15.00	31.52	8.89	3.26	13.50	***	151.86	56.97	162.19
P28	12.24	3.62	6.00	19.00	22.86	8.08	-10.62	no	-46.46	15.82	49.08
P29	13.16	3.29	7.47	19.00	21.05	6.21	-7.89	no	-37.48	15.63	40.61
P32	6.21	2.60	2.00	11.52	0.00	0.00	6.21	***	NA	NA	NA
P35	25.36	5.38	13.48	36.00	5.00	2.89	20.36	***	407.2	107.55	421.16
P36	76.53	9.76	60.00	96.52	8.00	3.27	68.53	***	856.62	121.95	865.26
P37	21.78	5.13	13.00	33.00	13.75	6.25	8.03	no	58.4	37.29	69.29
P38	62.28	9.15	45.48	83.52	18.67	9.65	43.61	***	233.58	49.01	238.67
P39	56.87	8.91	40.00	72.52	20.00	5.99	36.87	***	184.35	44.53	189.65
P40	38.11	7.21	24.48	52.00	28.89	8.59	9.22	no	31.91	24.97	40.52
Mean	**23.39**				**9.55**		**13.84**		**346.94**	**108.62**	**376.81**

Table 9 : Comparison of predicted and observed pole density (PoleQty, t/ha) for fir.

Statistical significance of differences between predicted and observed values (Student' t test) : non-significant (α = 0.05) for p-value ≥ 0.1 (no) and p-value ϵ [0.05, 0.1[(*), significant for p-value ϵ [0.01,0.05[(**) and very significant for p-value <0.01 (***).

Stand composition

Plot	Predicted values				Observed values		Comparison				
	Mean	SD	Inf 95%CI	Sup 95%CI	Mean	SE	mDiff	t.test	Bias	Precision	Accuracy
P1	100.00	0.00	100.00	100.00	93.73	5.53	6.27	no	6.69	0	6.69
P2	100.00	0.00	100.00	100.00	89.47	7.23	10.53	no	11.77	0	11.77
P4	97.52	1.06	94.94	99.50	69.69	9.76	27.83	**	39.94	1.51	39.97
P6	99.33	0.59	98.04	100.00	99.76	0.24	-0.43	no	-0.43	0.59	0.73
P7	92.53	1.70	89.27	95.78	89.68	4.27	2.85	no	3.18	1.9	3.7
P9	72.65	3.50	67.28	79.85	80.01	4.96	-7.36	no	-9.2	4.37	10.19
P11	82.58	2.92	76.90	88.16	77.32	7.29	5.26	no	6.81	3.77	7.78
P20	90.81	2.03	86.20	94.35	69.71	9.43	21.10	**	30.26	2.91	30.4
P21	82.54	2.81	77.33	88.21	54.96	11.04	27.58	**	50.18	5.11	50.44
P22	75.71	3.54	68.77	82.15	85.50	5.30	-9.79	*	-11.45	4.14	12.18
P25	62.52	4.31	54.78	69.54	37.46	7.99	25.06	***	66.89	11.52	67.87
P26	72.59	2.73	67.48	78.00	56.53	7.01	16.06	**	28.41	4.82	28.82
P27	74.66	3.34	68.38	80.53	74.08	4.24	0.58	no	0.78	4.51	4.58
P28	67.88	2.74	62.16	72.72	81.50	5.47	-13.62	**	-16.71	3.37	17.05
P29	78.72	2.67	74.62	83.98	72.16	6.53	6.56	no	9.09	3.7	9.81
P32	94.90	1.83	90.77	97.95	100.00	0.00	-5.10	***	-5.1	1.83	5.42
P35	80.32	3.10	73.73	84.79	68.82	8.94	11.50	no	16.71	4.51	17.31
P36	52.87	3.86	45.91	59.16	49.85	8.45	3.02	no	6.06	7.75	9.84
P37	71.63	2.97	65.99	77.27	66.31	8.88	5.32	no	8.03	4.47	9.19
P38	56.16	4.85	47.29	65.11	49.10	10.49	7.06	no	14.39	9.89	17.46
P39	54.55	3.69	47.79	60.88	42.87	9.21	11.68	no	27.24	8.61	28.57
P40	61.01	3.99	53.36	68.15	57.48	9.27	3.53	no	6.14	6.94	9.27
Mean	**78.25**				**71.18**		**7.07**		**13.17**	**4.37**	**18.14**

Table 10: Comparison of predicted and observed mixing ratio (MixR, % spruce).

NB: stand mixing ratio is calculated as spruce proportion over total basal area (m²/ha).

Statistical significance of differences between predicted and observed values (Student' t test) : non-significant ($\alpha = 0.05$) for p-value ≥ 0.1 (no) and p-value ϵ [0.05, 0.1[(*), significant for p-value ϵ [0.01,0.05[(**) and very significant for p-value <0.01 (***).

Plot	Predicted values				Observed values		Comparison				
	Mean	SD	Inf 95%CI	Sup 95%CI	Mean	SE	mDiff	t.test	Bias	Precision	Accuracy
P1	100.00	0.00	100.00	100.00	88.89	7.86	11.11	no	12.5	0	12.5
P2	100.00	0.00	100.00	100.00	80.00	9.67	20.00	no	25	0	25
P4	98.36	0.91	96.90	100.00	62.50	15.61	35.86	no	57.38	1.46	57.4
P6	99.43	0.89	97.26	100.00	100.00	0.00	-0.57	***	-0.57	0.89	1.06
P7	90.99	3.50	83.59	97.51	82.05	7.23	8.94	no	10.9	4.27	11.71
P9	80.87	4.39	71.43	89.28	27.00	9.11	53.87	**	199.5	16.27	200.16
P11	86.32	2.81	79.91	91.75	0.00	0.00	86.32	***	NA	NA	NA
P20	91.22	2.40	86.48	96.15	35.00	10.11	56.22	***	160.62	6.86	160.77
P21	88.97	2.13	84.99	93.00	43.75	14.30	45.22	**	103.37	4.88	103.49
P22	78.93	3.94	70.74	85.65	58.33	12.69	20.60	no	35.31	6.76	35.95
P25	64.80	4.00	56.16	72.40	12.25	5.84	52.55	***	428.95	32.66	430.19
P26	78.67	4.40	69.01	87.98	23.33	8.89	55.34	***	237.19	18.87	237.94
P27	78.99	4.06	71.28	84.96	49.86	7.34	29.13	**	58.42	8.14	58.98
P28	62.72	7.73	49.25	77.11	30.00	11.46	32.72	**	109.05	25.77	112.05
P29	80.28	4.58	72.34	87.79	29.74	6.98	50.54	***	169.96	15.4	170.66
P32	95.19	2.02	91.29	98.42	100.00	0.00	-4.81	***	-4.81	2.02	5.22
P35	85.42	3.01	79.84	92.27	40.00	6.77	45.42	**	113.55	7.53	113.8
P36	69.54	2.99	63.94	74.83	33.33	16.33	36.21	no	108.65	8.97	109.02
P37	73.21	5.31	62.16	82.87	41.48	11.60	31.73	*	76.49	12.79	77.55
P38	63.86	4.16	55.58	71.54	26.79	11.74	37.07	*	138.38	15.54	139.25
P39	61.72	4.39	53.94	69.38	27.78	10.34	33.94	**	122.16	15.81	123.18
P40	65.42	5.30	55.85	76.07	19.51	8.74	45.91	***	235.31	27.16	236.87
Mean	**81.59**				**45.98**		**35.61**		**114.16**	**11.05**	**115.37**

Table 11: Comparison of predicted and observed pole mixing ratio (PoleMixR, % spruce).

NB: pole mixing ratio is calculated as spruce proportion over total pole density (t/ha).

Statistical significance of differences between predicted and observed values (Student' t test) : non-significant ($\alpha = 0.05$) for p-value ≥ 0.1 (no) and p-value ϵ [0.05, 0.1[(*), significant for p-value ϵ [0.01,0.05[(**) and very significant for p-value <0.01 (***).

III. DIAMETER DISTRIBUTIONS COMPARISON

1) Qualitative comparison

We graphically assessed the consistency of predicted *versus* observed diameter distributions. However, as results were very variable among stands, it appeared difficult to draw general results from this qualitative comparison. We therefore needed a method to quantify the distance between distributions, as detailed in the following section.

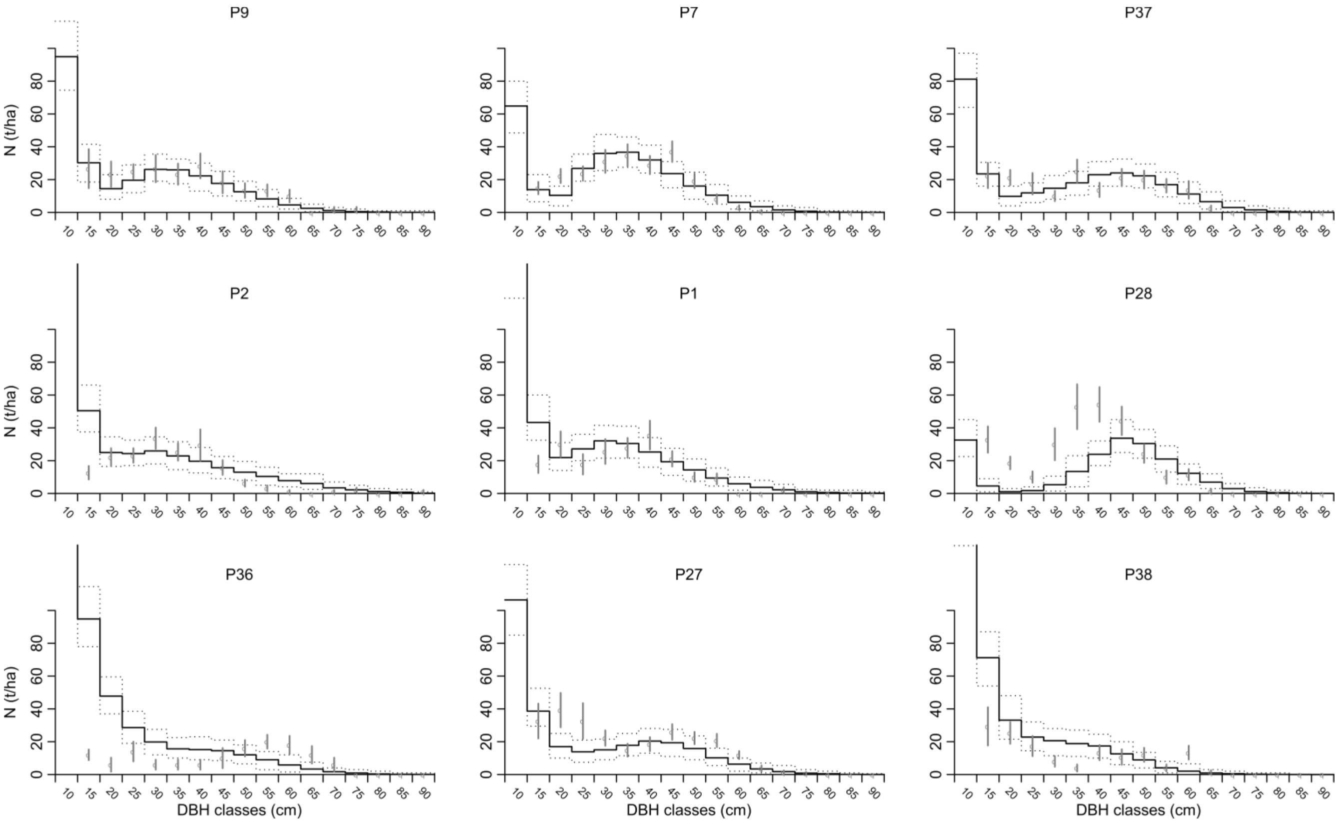

Figure 1: Qualitative comparison of stand diameter distribution, for a selection of stands.

This figure compares predicted and observed diameter distributions at the end of the simulation for a selection of stands. It shows the mean predicted distribution (*solid line*) and 95% confidence intervals (*dotted lines*) to the mean distribution observed in 1980 (*grey circles*) and the related standard errors of the mean (*grey bars*). The first line presents three cases with good adequacy between predicted and observed simulations, while the second and third lines respectively present cases with an over- or under-estimation of large trees.

2) Quantitative comparison

We first assessed the differences between distributions by comparing the numbers of trees per size category (**Erreur ! Source du renvoi introuvable.**). However, as these results were affected by potential prediction bias of the total number of trees, we looked for a method to compare the frequencies per class in a simple way, and thus quantify differences between diameter distributions.

We then quantified the discrepancies between predicted and observed diameter distributions using Pearson's Chi-square test (Pearson, 1900), as recommended by Reynolds *et al.* (1988). This test assesses the equality of distributions of individuals among k classes based on the frequency per class, i.e. irrespectively of the total number of individuals. It is classically based on the comparison between an "observed" (linked to an "observation") and an "expected" distribution (cf. Eq. (B.6)). Here, our "observation" is, in fact, a "prediction" made by the model, while the reference distribution is estimated from the "observed" distribution (field inventory). We thus changed the formula to Eq. (B.6') to better fit our glossary. Thus, for each class i, the test compare the "predicted" number of individuals in i (P_i) to the "expected" number of individuals in i (E_i) (cf. Eq. (B.6')). The latter is calculated from the total number of predicted individuals (n_P) and the observed frequency for class i, i.e. the ratio of observed individuals in class i (O_i) over the total number of "observed" individuals (n_O) (cf. Eq. (B.7)).

The estimated χ^2 is then compared to a threshold (maximum) χ^2 value to determine whether both predicted and observed distributions are equal – or not. This threshold χ^2 depend on the α risk and number of degree of freedom (df) and thus on the number of classes k (Eq. (B.8)). With $\alpha = 0.05$, we have $\chi^2 = 5.99$ for $df = 2$ (test based on three size categories: small, medium and large trees; cf. Table 13).

$$Eq.(B.6)\ \chi^2 = \sum_{i}^{k} \frac{(O_i - E_i)^2}{E_i}$$

$$Eq.(B.6')\ \chi^2 = \sum_{i}^{k} \frac{(P_i - E_i)^2}{E_i}$$

$$Eq.(B.7)\ E_i = \frac{O_i}{n_O} \times n_P$$

$$Eq.(B.8)\ df = k - 1$$

Chi-square tests have been automatically conducted with the *chisq.test()* R function (R Core Team, 2012) in two ways. The first way compared the mean predicted distribution (on the R=100 repetitions) to the mean observed one (estimated after several different inventory sampling plots). The results are presented in the first set of columns of Table 13. The second way consisted in comparing all predicted distributions (all repetitions) to the mean observed distribution. The results are presented in the second set of columns of Table 13.

Stand	Small	Medium	Large	Mean Difference
1	2.62	-1.21	35.45	12.29
2	8.79	-22.64	99.79	28.65
4	-18.75	19.87	19.08	6.73
6	-50.90	-26.39	-2.59	-26.63
7	-19.02	10.34	-8.52	-5.73
9	-29.49	-4.96	-18.59	-17.68
11	45.23	-1.51	10.66	18.13
20	15.86	-12.86	6.65	3.22
21	98.33	140.15	-14.62	74.62
22	15.72	90.91	-14.88	30.58
25	0.80	67.00	10.48	26.09
26	-36.54	35.42	-28.28	-9.80
27	-57.05	-4.28	-32.78	-31.37
28	-90.20	-68.96	19.13	-46.68
29	-40.29	58.05	18.58	12.11
32	48.74	25.14	-6.73	22.38
35	100.99	121.87	10.50	77.78
36	282.05	181.17	-41.62	140.53
37	-44.13	14.34	17.27	-4.17
38	31.18	124.25	-28.90	42.18
39	10.74	113.20	20.95	48.30
40	-14.43	48.28	20.63	18.16
Mean	**11.83**	**41.24**	**4.17**	**19.08**

Table 12: Comparison of the predicted and observed number of trees per size category class (t/ha).

This table presents results of the comparison of predicted versus observed number of trees per size category class (in t/ha), i.e. for small (diameter ϵ [17.5, 27.5[cm), medium (diameter ϵ [27.5, 42.5[cm) and large (diameter ≥ 42.5 cm) trees.

Plot	*Mean predicted VS mean observed distributions*			*All predicted VS mean observed distributions*		
	Chi2	p-value	Equality	Mean Chi2	Mean p-value	%equal distributions
1	3.75	1.53E-01	yes	5.39	2.04E-01	65%
2	31.27	1.62E-07	no	32.77	1.30E-05	0%
4	5.62	6.01E-02	yes	7.30	9.70E-02	42%
6	9.41	9.05E-03	no	10.96	3.73E-02	19%
7	3.13	2.09E-01	yes	4.41	2.28E-01	74%
9	2.22	3.30E-01	yes	3.95	2.99E-01	80%
11	4.40	1.11E-01	yes	6.00	1.71E-01	56%
20	2.71	2.58E-01	yes	4.23	2.64E-01	78%
21	37.63	6.74E-09	no	39.67	2.98E-06	0%
22	21.25	2.43E-05	no	22.90	1.75E-03	2%
25	7.57	2.27E-02	no	9.34	5.95E-02	28%
26	21.20	2.49E-05	no	22.75	1.41E-03	1%
27	13.14	1.40E-03	no	14.79	1.48E-02	7%
28	NA	NA	NA	NA	NA	0%
29	20.81	3.03E-05	no	22.51	1.10E-03	1%
32	5.89	5.25E-02	yes	7.29	1.18E-01	45%
35	16.31	2.87E-04	no	18.12	7.39E-03	3%
36	142.22	1.31E-31	no	144.38	1.70E-22	0%
37	10.53	5.16E-03	no	11.78	1.55E-02	7%
38	28.34	7.03E-07	no	30.40	8.49E-04	0%
39	13.82	9.99E-04	no	15.27	1.18E-02	7%
40	6.15	4.62E-02	no	7.62	9.94E-02	45%
Mean	**19.40**			**21.04**		**25.45%**

Table 13: Chi-square test results at the stand level.

This table presents the results of chi-square tests conducted between the mean observed distribution and the mean predicted distribution (left set of columns) or all predicted distributions (right set of columns). The initial 5cm diameter distributions were grouped into three size categories representing small (diameter ϵ [17.5, 27.5[cm), medium (diameter ϵ [27.5, 42.5[cm) and large (diameter ≥ 42.5 cm) trees. The number of degree of freedom for the test was thus $df = 2$, and $\chi^2 < 5.99$ indicated equal distributions. The chi-square test could not be applied for P28 because one of the class was empty (category “small”).

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