

Tree Growth Submodels for the US Northern Forest

Results for Operational Versions

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Diameter Growth Submodel

Table 1: Results of diameter growth submodel, tested against an independent dataset. Diameter growth is measured in inches per year.

<i>Species</i>	<i>n</i>	<i>mean Δdbh</i>	<i>RMSE</i>	<i>nRMSE</i>	<i>MAE</i>	<i>R²</i>
fir	15165	0.080	0.0101	0.126	0.0070	0.957
spruce	10580	0.066	0.0086	0.130	0.0062	0.932
soft maple	9048	0.071	0.0062	0.087	0.0045	0.963
hard maple	5292	0.086	0.0091	0.106	0.0063	0.936
cedar	5248	0.056	0.0064	0.114	0.0048	0.895
beech	4600	0.080	0.0071	0.089	0.0053	0.964
yellow birch	4070	0.065	0.0066	0.102	0.0048	0.946
paper birch	3800	0.058	0.0058	0.100	0.0042	0.945
hemlock	3287	0.116	0.0104	0.090	0.0078	0.952
white pine	2351	0.149	0.0177	0.119	0.0128	0.935
aspen	1848	0.090	0.0076	0.084	0.0053	0.974
ash	1708	0.085	0.0076	0.089	0.0051	0.972
other hardwood	1163	0.043	0.0097	0.226	0.0069	0.904
striped maple	1092	0.023	0.0059	0.257	0.0036	0.911
red oak	750	0.148	0.0147	0.099	0.0110	0.950
black cherry	504	0.064	0.0080	0.125	0.0058	0.931
hophornbeam	445	0.044	0.0093	0.211	0.0072	0.925
tamarack	382	0.042	0.0159	0.379	0.0122	0.767
norway spruce	216	0.037	0.0174	0.470	0.0146	0.812
elm	167	0.060	0.0090	0.150	0.0066	0.920
red pine	167	0.167	0.0283	0.169	0.0225	0.888
basswood	125	0.078	0.0188	0.241	0.0146	0.620
white oak	55	0.082	0.0208	0.254	0.0167	0.580
hickory	51	0.142	0.0164	0.115	0.0128	0.905
other softwood	40	0.043	0.0390	0.907	0.0356	0.338
scots pine	12	0.072	0.0617	0.857	0.0525	0.434
butternut	9	0.080	0.0070	0.088	0.0057	0.950
cottonwood	8	0.162	0.0898	0.554	0.0648	0.379
Combined	72183	0.077	0.0092	0.119	0.0062	0.958

Height Submodel

Table 2: Results of total height submodel, tested against an independent dataset. Height is measured in feet.

<i>Species</i>	<i>n</i>	<i>mean height</i>	<i>RMSE</i>	<i>nRMSE</i>	<i>MAE</i>	<i>R²</i>
fir	8668	38.254	6.0615	0.158	4.7254	0.712
spruce	7998	44.119	6.5018	0.147	5.0940	0.765
soft maple	7053	52.514	7.7228	0.147	6.0505	0.623
hard maple	4261	55.905	8.1302	0.145	6.4092	0.628
cedar	4225	38.519	5.9381	0.154	4.5962	0.622
yellow birch	3308	49.283	7.7522	0.157	6.1210	0.593
beech	3207	45.380	8.2155	0.181	6.4265	0.579
paper birch	3022	46.149	6.8784	0.149	5.4216	0.639
hemlock	2919	45.026	8.3610	0.186	6.6048	0.701
white pine	2079	53.281	9.3608	0.176	7.3831	0.822
aspen	1715	57.675	8.3944	0.146	6.5089	0.665
ash	1423	54.040	8.8150	0.163	6.9018	0.651
red oak	599	57.940	9.3022	0.161	7.3396	0.530
other hardwood	537	35.838	9.6955	0.271	7.4841	0.388
black cherry	494	52.960	9.2482	0.175	7.2037	0.664
red pine	393	46.840	8.4569	0.181	7.2442	0.915
tamarack	276	56.931	10.4692	0.184	8.6219	0.812
hophornbeam	243	43.230	7.2770	0.168	5.8168	0.278
striped maple	215	32.670	6.2470	0.191	4.8724	0.681
elm	181	44.989	7.1845	0.160	5.7058	0.558
norway spruce	165	55.655	7.9446	0.143	6.1768	0.675
basswood	90	54.111	7.5438	0.139	5.6710	0.687
white oak	78	45.910	7.2185	0.157	5.4094	0.765
hickory	66	61.545	15.5868	0.253	13.3014	0.503
scots pine	65	51.923	11.2545	0.217	8.7622	0.430
other softwood	64	48.219	13.1091	0.272	10.1022	0.681
cottonwood	12	63.833	14.5137	0.227	11.4774	0.645
butternut	6	56.000	10.7062	0.191	7.9557	0.076
<i>Combined</i>	<i>53362</i>	<i>46.681</i>	<i>7.4671</i>	<i>0.160</i>	<i>5.7885</i>	<i>0.738</i>

Height Growth Submodel

Table 3: Results of height growth submodel, tested against an independent dataset. Height growth is measured in feet per year.

<i>Species</i>	<i>n</i>	<i>mean Δht</i>	<i>RMSE</i>	<i>nRMSE</i>	<i>MAE</i>	<i>R²</i>
fir	7478	0.680	1.0329	1.519	0.7796	0.008
spruce	7439	0.427	1.0576	2.477	0.7843	0.000
soft maple	6831	0.326	1.4249	4.371	1.0954	0.004
cedar	4229	0.148	1.1538	7.796	0.8721	0.024
hard maple	4074	0.225	1.4427	6.412	1.1013	0.002
beech	3167	0.304	1.4059	4.625	1.0749	0.003
hemlock	3153	0.555	1.1023	1.986	0.8256	0.000
yellow birch	3065	0.364	1.4510	3.986	1.1075	0.004
paper birch	2614	0.128	1.4391	11.243	1.0947	0.005
white pine	2162	0.866	1.3530	1.562	1.0084	0.004
aspen	1487	0.635	1.5429	2.430	1.2025	0.003
ash	1333	0.380	1.5489	4.076	1.2107	0.002
red oak	767	0.609	1.5518	2.548	1.2164	0.020
other hardwood	443	0.431	1.2042	2.794	0.9206	0.000
black cherry	404	0.755	1.3431	1.779	1.0218	0.000
tamarack	404	0.768	1.3044	1.698	1.0255	0.013
hophornbeam	279	0.242	1.2902	5.331	0.9832	0.021
norway spruce	221	0.923	1.1295	1.224	0.8393	0.098
red pine	212	0.568	1.0897	1.918	0.8915	0.018
elm	154	0.868	1.2468	1.436	0.9696	0.000
striped maple	128	0.333	1.0965	3.293	0.8777	0.001
basswood	120	0.769	1.4976	1.947	1.1409	0.006
white oak	70	0.555	1.1386	2.052	0.8558	0.012
hickory	57	1.058	1.3366	1.263	0.9553	0.017
scots pine	40	-0.162	1.2725	-7.855	1.1382	0.154
butternut	9	0.840	1.3837	1.647	1.0679	0.220
cottonwood	4	0.789	1.1628	1.474	0.9614	0.643
other softwood	4	0.039	0.9683	24.828	0.8199	0.234
<i>Combined</i>	<i>50348</i>	<i>0.428</i>	<i>1.2822</i>	<i>2.996</i>	<i>0.9645</i>	<i>0.002</i>

Crown Ratio Change Submodel

Table 4: Results of crown ratio change submodel, tested against an independent dataset. Crown ratio change is measured in change of percent per year, with positive numbers indicating increasing crown ratios.

<i>Species</i>	<i>n</i>	<i>mean ΔCR</i>	<i>RMSE</i>	<i>nRMSE</i>	<i>MAE</i>	<i>R²</i>
fir	15165	-1.151	3.0326	-2.635	2.3486	0.010
spruce	10580	-0.553	2.9367	-5.310	2.2625	0.003
soft maple	9048	0.030	2.5559	85.197	1.9481	0.012
hard maple	5292	0.128	2.6913	21.026	2.0492	0.020
cedar	5248	-0.223	3.2061	-14.377	2.4567	0.057
beech	4600	0.019	3.5787	188.353	2.7307	0.022
yellow birch	4070	-0.002	2.9180	-1459.000	2.2232	0.027
paper birch	3800	-0.241	2.4172	-10.030	1.8417	0.003
hemlock	3287	0.117	3.1991	27.343	2.4798	0.042
white pine	2351	-0.620	2.7964	-4.510	2.1421	0.003
aspen	1848	-0.212	2.5440	-12.000	1.9422	0.008
ash	1708	-0.196	2.5844	-13.186	1.9405	0.001
other hardwood	1163	-0.731	3.3557	-4.591	2.5649	0.021
striped maple	1092	-0.510	2.8748	-5.637	2.1762	0.011
red oak	750	0.605	2.6174	4.326	1.9350	0.076
black cherry	504	-0.292	2.3854	-8.169	1.7816	0.004
hophornbeam	445	-0.367	3.0676	-8.359	2.3894	0.005
tamarack	382	-0.468	2.8352	-6.058	2.2444	0.000
norway spruce	216	-0.333	2.6860	-8.066	2.0722	0.001
elm	167	-0.560	2.8857	-5.153	2.2877	0.000
red pine	167	-0.667	2.3757	-3.562	1.8691	0.134
basswood	125	-0.015	2.5354	-169.027	1.8886	0.003
white oak	55	-0.386	2.6739	-6.927	2.2777	0.012
hickory	51	-0.141	1.8380	-13.035	1.5079	0.001
other softwood	40	-0.292	1.7061	-5.843	1.1633	0.053
scots pine	12	-0.840	1.9206	-2.286	1.6098	0.060
butternut	9	-0.834	2.5043	-3.003	2.1618	0.572
cottonwood	8	-1.549	2.9940	-1.933	2.3391	0.029
<i>Combined</i>	<i>72183</i>	<i>-0.387</i>	<i>2.9217</i>	<i>-7.550</i>	<i>2.2295</i>	<i>0.001</i>

Survival Submodel

Where results depend on a positive class, the positive class is “lived”.

Table 5: Overall accuracy estimates, calculated on independent data

	x
Accuracy	0.959
Kappa	0.131
AccuracyLower	0.957
AccuracyUpper	0.960
AccuracyNull	0.957
AccuracyPValue	0.020
McnemarPValue	0.000

Table 6: Accuracy estimates by class, calculated on independent data

	x
Sensitivity	0.078
Specificity	0.998
Pos Pred Value	0.645
Neg Pred Value	0.960
Precision	0.645
Recall	0.078
F1	0.139
Prevalence	0.043
Detection Rate	0.003
Detection Prevalence	0.005
Balanced Accuracy	0.538

Table 7: Confusion matrix. Columns are actual, observed outcomes; rows are predicted outcomes.

	died	lived
died	258	142
lived	3058	73841

The AUROC, calculated on independent data, was estimated to be 0.8135774, with a confidence interval between 0.8057681 and 0.8213867.