**Table S1**. Height and diameter equations used for inventory data update (Guzmán Álvarez et. al., 2012). Diameter at breast height ($D_i$, cm), number of stems (N, trees $ha^{-1}$), height ($H_i$, m), Site Index (IS) competition index ($IC_i$) tree age ($E_i$), biomass fractions (stem $W_s$, thick branches $W_{tkb}$, medium branches $W_{mb}$, thin branches $W_{tnb}$, roots $W_r$, thick-medium branches $W_{tkmb}$).

| Species | Equations for inventory data update | Equations for tree age update | Equations for biomass estimation | |
|---|---|---|---|---|
| | | | Biomass fraction | Equations |
| *Pinus halepensis* | $H_i = e^{-3,7991+0,94876\cdot ln(Ei)+1,0459\cdot ln(IS)}$ | $H_i = e^{(ln(di)+0,1073*ln(N_i)+0,00046*ln(ICi)-1,4971)/0,9398}$ | Stem | $W_s = 0.0139\cdot d^2\cdot H$ |
| | | | Thick branches | For d >27.5 cm<br>$W_{tkb} = 3.926\cdot(d-27.5)$ |
| | $d_i = e^{1,4971+0,9398\cdot ln(Hi)-0,1073\cdot ln(N_i)-0,00046ln(ICi)}$ | $E_i = e^{(ln(Hi)-1,0459*ln(IS)+3,7991)/0,94876}$ | Medium branches | $W_{mb} = 4.257+0.00506\cdot d^2\cdot H-0.0722\cdot d\cdot H$ |
| | | | Thin branches | $W_{tnb} = 6.197 +0.00932\cdot d^2\cdot H-0.0686\cdot d\cdot H$ |
| | | | Roots | $W_r = 0.0785\cdot d^2$ |
| *Pinus pinaster* | $H_i = e^{-3,9777+1,0166\cdot ln(Ei)+1,0182\cdot ln(IS)}$ | $H_i = e^{(ln(di)+0,0934*ln(N_i)+0,00026*ln(ICi)-1.1049)/1.1004}$ | Stem | $W_s = 0.0278\cdot d^{2.115}\cdot H^{0.618}$ |
| | | | Thick-medium branches | $W_{tkmb} = 0.000381\cdot d^{3.141}$ |
| | $d_i = e^{0,8671+1,1349\cdot ln(Hi)-0,0499\cdot ln(N_i)-0,000053ln(ICi)}$ | $E_i = e^{(ln(Hi)-1,0182*ln(IS)+3,9777)/1,0166}$ | Thin branches | $W_{tnb} = 0.0129\cdot d^{2.32}$ |
| | | | Roots | $W_r = 0.00444\cdot d^{2.804}$ |
| *Pinus nigra* | $H_i = e^{-4,1267+1,0454\cdot ln(Ei)+1,0189\cdot ln(IS)}$ | $H_i = e^{(ln(di)+0,0499*ln(N_i)+0,000053*ln(ICi)-0,8671)/1,1349}$ | Stem | $W_s = 0.0403\cdot d^{1.838}\cdot H^{0.945}$ |
| | | | Thick branches | For d >32.5 cm<br>$W_{tkb} = 0.228\cdot(d-32.5)^2$ |
| | $d_i = e^{1,1049+1,1004\cdot ln(Hi)-0,0934\cdot ln(N_i)-0,00042\cdot ln(ICi)}$ | $E_i = e^{(ln(Hi)-1,0189*ln(IS)+4,1267)/1,0454}$ | Medium branches | $W_{mb} = 0.0521\cdot d^2$ |
| | | | Thin branches | $W_{tnb} = 0.0720\cdot d^2$ |
| | | | Roots | $W_r = 0.0189\cdot d^{2.445}$ |
| *Pinus sylvestris* | $H_i = e^{-4,0619+1,0176\cdot ln(Ei)+1,0329\cdot ln(IS)}$ | $H_i = e^{(ln(di)+0,1056*ln(N_i)+0,000723*ln(ICi)-1,7441)/0,8306}$ | Stem | $W_s = 0.0154\cdot d^2\cdot H$ |
| | | | Thick branches | For d >32.5 cm<br>$W_{tkb} = 0.54\cdot(d-37.5)^2-0.0119\cdot(d-37.5)^2\cdot H$ |
| | $d_i = e^{1,7441+0,8306\cdot ln(Hi)-0,1056\cdot ln(N_i)-0,000723\cdot ln(ICi)}$ | $E_i = e^{(ln(Hi)-1,0329*ln(IS)+4,0619)/1,0176}$ | Medium branches | $W_{mb} = 0.0295\cdot d^{2.745}\cdot H^{-0.899}$ |
| | | | Thin branches | $W_{tnb} = 0.53\cdot d^{2.199}\cdot H^{-1.153}$ |
| | | | Roots | $W_r = 0.13\cdot d^2$ |

**Table S2**. Selected LiDAR metrics parameters to run statistical analyses (McGaughey, 2018).

| Abbreviation | LiDAR metric |
|---|---|
| Total.return.count | Total number of all returns of the plot |
| Return.1.count | Count of returns of return number 1 within the plot |
| Return.2.count | Count of returns of return number 2 within the plot |
| Elev.minimum | Minimum elevation from all returns of the plot |
| Elev.maximum | Maximum elevation from all returns of the plot |
| Elev.mean | Mean elevation from all returns of the plot |
| Elev.mode | Mode elevation from all returns of the plot |
| Elev.stddev | Standard deviation of elevations within the plot |
| Elev.variance | Variance of elevations within the plot |
| Elev.CV | Coefficient of variation of elevations within the plot |
| Elev.IQ | Interquartile distance of elevations within the plot |
| Elev.skewness | Skewness of the elevation from all returns of the plot |
| Elev.kurtosis | Kurtosis of the elevation from all returns of the plot |
| Elev.AAD | Average Absolute Deviation |
| Elev.MAD.median | Median of the absolute deviations from the overall median |
| Elev.MAD.mode | Median of the absolute deviations from the overall mode |
| Elev.L1 | First L-moment of the return heights of the plot |
| Elev.L2 | Second L-moment of the return heights of the plot |
| Elev.L4 | Third L-moment of the return heights of the plot |
| Elev.L.CV | L-moment coefficient of variation of the return heights of the plot |
| Elev.L.skewness | L-moment skewness of the return heights of the plot |
| Elev.L.kurtosis | L-moment kurtosis of the return heights of the plot |
| Elev.P50 | 50th percentile of the return heights of the plot |
| Elev.P60 | 60th percentile of the return heights of the plot |
| Elev.P70 | 70th percentile of the return heights of the plot |
| Elev.P75 | 75th percentile of the return heights of the plot |
| Elev.P80 | 80th percentile of the return heights of the plot |
| Elev.P90 | 90th percentile of the return heights of the plot |
| Elev.P95 | 95th percentile of the return heights of the |

| Abbreviation | LiDAR metric |
|---|---|
| | plot |
| Elev.P99 | 99th percentile of the return heights of the plot |
| Canopy.relief.ratio | (mean height- min height) / (max height – min height) |
| Elev.SQRT.mean.SQ | Generalized means for the 2nd power |
| Elev.CURT.mean.CUBE | Generalized means for the 3rd power |
| Percentage.first.returns.above.200 | Percentage of first returns above 2 meters |
| Percentage.all.returns.above.200 | Percentage of all returns above 2 meters |
| All.returns.above.200...Total.first.returns...100 | Number of returns above 2 meters / total first returns * 100 |
| First.returns.above.200 | Number of first returns above 2 meters |
| All.returns.above.200 | Number of all returns above 2 meters |
| Percentage.first.returns.above.mean | Percentage of first returns above mean height |
| Percentage.first.returns.above.mode | Percentage of first returns above mode height |
| Percentage.all.returns.above.mean | Percentage of all returns above mean height |
| Percentage.all.returns.above.mode | Percentage of all returns above mode height |
| All.returns.above.mean...Total.first.returns...100 | Number of returns above the mean height / total first returns * 100 |
| All.returns.above.mode...Total.first.returns...100 | Number of returns above the mode height / total first returns * 100 |
| First.returns.above.mean | Number of first returns above the mean height of the plot |
| First.returns.above.mode | Number of first returns above the mode height of the plot |
| All.returns.above.mean | Number of all returns above the mean height of the plot |
| All.returns.above.mode | Number of all returns above the mode height of the plot |
| Total.first.returns | Number of first returns of the plot |
| Total.all.returns | Number of all returns of the plot |

**Table S3.** Root mean square error (RMSE) and bias of bivariate relationships between observed and predicted C stock in live-biomass ($MgC \cdot ha^{-1}$) and Soil Carbon stock ($SOC_{depth}$ , $MgC \cdot ha^{-1}$) k-NN model with RF distance calculation.

| | | Internal validation | External validation | Cross-validation |
|---|---|---|---|---|
| Biomass stock *P. halepensis* | RMSE | 4.07 | 4.01 | 5.26 |
| | RMSE % | 40.00 | 41.55 | 52.50 |
| | BIAS | -0.29 | -0.55 | -0.41 |
| | BIAS % | -2.89 | -5.70 | -4.07 |
| Biomass stock *P. nigra* | RMSE | 18.96 | 27.38 | 20.86 |
| | RMSE % | 39.15 | 62.35 | 44.35 |
| | BIAS | 0.15 | -3.98 | 0.25 |
| | BIAS % | 0.31 | -9.06 | 0.53 |
| Biomass stock *P. pinaster* | RMSE | 8.18 | 21.00 | 16.56 |
| | RMSE % | 14.55 | 41.43 | 30.38 |
| | BIAS | -0.72 | 0.47 | 0.92 |
| | BIAS % | -1.28 | 0.92 | 1.68 |
| Biomass stock *P. sylvestris* | RMSE | 13.47 | 34.99 | 33.45 |
| | RMSE % | 36.88 | 101.38 | 93.13 |
| | BIAS | 0.67 | -3.14 | -0.80 |
| | BIAS % | 1.84 | -9.10 | -2.24 |
| $SOC_{10}$ stock (0-10 cm soil layer) | RMSE | 3.21 | 6.29 | 4.92 |
| | RMSE % | 44.49 | 67.37 | 62.64 |
| | BIAS | -0.20 | -0.44 | -0.32 |
| | BIAS % | -2.80 | -4.72 | -4.11 |
| $SOC_{40}$ stock (0-40 cm soil layer) | RMSE | 8.69 | 14.01 | 12.92 |
| | RMSE % | 33.87 | 42.39 | 46.35 |
| | BIAS | -0.39 | -0.64 | -0.31 |
| | BIAS % | -1.52 | -1.95 | -1.09 |

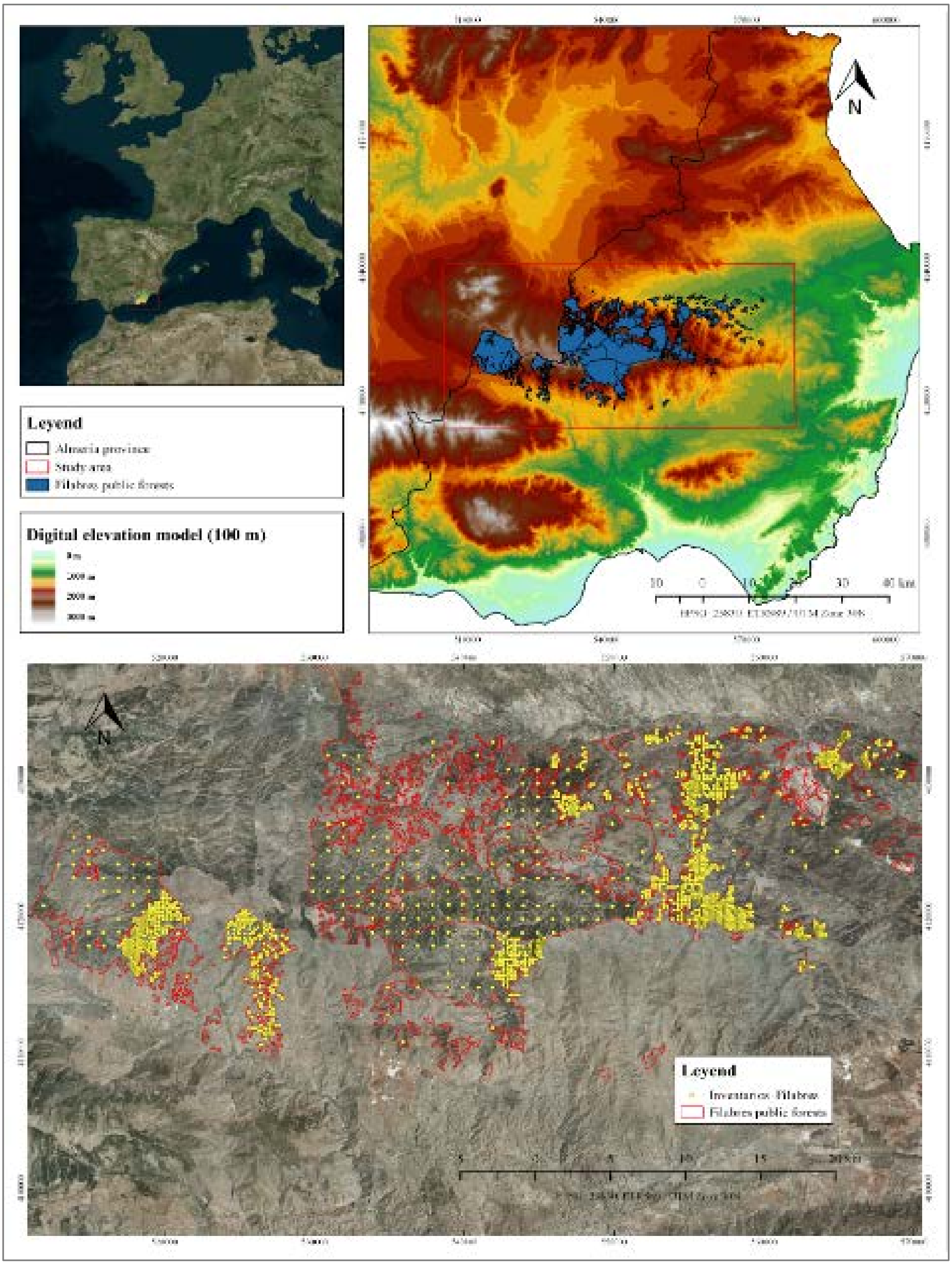


**Figure S1.** Study area in Sierra de los Filabres (Almería province, Andalusia. South-eastern Spain) showing the distribution of field plots corresponding to performed forests inventories within Filabres public forests.