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*Supplement of*

# Influence of wood density in tree-ring based annual productivity assessments and its errors in Norway spruce

**O. Bouriaud et al.**

*Correspondence to:* O. Bouriaud (obouriaud@gmail.com)

## *Supplement S1. Sampling plot location, stand and tree characteristics*

| | Plot ID | Plot area m$^2$ | Altitude m a.s.l. | Stand age | N trees total plot | N trees sampled | dbh range sampled trees cm | height range sampled trees m |
|---|---|---|---|---|---|---|---|---|
| **WD dataset** | | | | | | | | |
| | 4 | 625 | 733 | 10 | 132 | 3 | 2.1 – 6.2 | 2.3 – 5.0 |
| | 9 | 625 | 759 | 15 | 144 | 3 | 7.3 – 13.4 | 6.0 – 9.6 |
| | 33 | 625 | 727 | 35 | 39 | 3 | 16.9 – 35.3 | 17.6 – 20.5 |
| | 67 | 2500 | 784 | 75 | 127 | 3 | 19.7 – 46.0 | 18.0 – 24.7 |
| | 114 | 2500 | 738 | 115 | 66 | 3 | 27.7 – 59.5 | 23.7 – 31.8 |
| | | | | | | | | |
| **Stem analysis** | | | | | | | | |
| | 4 | 625 | 733 | 10 | 132 | 5 | 2.1 – 6.2 | 2.3 – 5.0 |
| | 9 | 625 | 759 | 15 | 144 | 5 | 7.3 – 13.4 | 6.0 – 9.6 |
| | 33 | 625 | 727 | 35 | 39 | 5 | 16.9 – 35.3 | 16.9 – 20.9 |
| | 67 | 2500 | 784 | 75 | 127 | 7 | 19.7 – 46.0 | 18.0 – 24.7 |
| | 114 | 2500 | 738 | 115 | 66 | 5 | 27.7 – 59.5 | 23.7 – 31.8 |
| | | | | | | | | |
| **Application set** | | | | | | | | |
| | IP2 | 707 | 773 | 55 | 36 | 36 | 19.1 – 48.9 | NA |
| | IP4 | 707 | 785 | 50 | 55 | 55 | 11.8 – 34.3 | NA |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | IP7 | 707 | 766 | 50 | 62 | 62 | 11.9 – 35.8 | NA |
| | P11 | 707 | 777 | 75 | 37 | 37 | 12.4 – 44.5 | NA |
| | P15 | 707 | 775 | 55 | 35 | 35 | 17.1 – 43.8 | NA |
| | P16 | 707 | 764 | 45 | 39 | 39 | 13.5 – 38.9 | NA |
| | P3 | 707 | 778 | 55 | 38 | 38 | 11.5 – 38.0 | NA |
| | P4 | 707 | 763 | 40 | 37 | 37 | 14.2 – 41.1 | NA |
| | P6 | 707 | 771 | 60 | 53 | 53 | 10.2 – 42.7 | NA |
| | P7 | 707 | 778 | 50 | 40 | 40 | 12.4 – 44.5 | NA |
| | P8 | 707 | 774 | 60 | 31 | 31 | 8.1 – 43.3 | NA |
| | W57 | 707 | 785 | 75 | 35 | 35 | 22.0 – 42.7 | NA |
| | W60 | 2500 | 733 | 75 | 53 | 53 | 19.6 – 50.7 | NA |

## *Supplement S2. WinBUGS code*

```
# Level 2: wood density as a function of ring width and size

for(i in 1:Ndata1){
        wd[i] ~ dnorm(mu.wd[i], tau.wd)
        mu.wd[i] <- a[1] +u[1,tree1[i]]
                        + (a[2]+u[2,tree1[i]])*pow(rw1[i], 0.5)
                        + (a[3]+u[3,tree1[i]])/pow(diam1[i],0.5) }


# Random terms, centered by a1-a3
for (j in 1:Ntree1){ u[1,j]~dnorm(0, tau.u[1])
                        u[2,j]~dnorm(0, tau.u[2])
                        u[3,j]~dnorm(0, tau.u[3]) }
# Prior
tau.wd <- 1/(sd.wd*sd.wd)   # Residual variance
 sd.wd ~ dunif(0,100)
  a[1] ~ dnorm(500,0.001)
for(i in 2:3){ a[i] ~ dnorm(0,0.001)  }          # Fixed coefficients
for(i in 1:3){ tau.u[i] <- 1/(sd.u[i]*sd.u[i])   # Random effects
                sd.u[i] ~ dunif(0,1000)
                }


# Level 2: volume increment as a function of ring width and size
for(i in 1:Ndata2){
        dv[i] ~ dnorm(mu.dv[i], tau.dv[i]) # Likelihood model for volume increment (dv)
        mu.dv[i] <- b[1]+b[2]*(pow((2*diam2[i]), b[3])*pow(rw2[i], b[4]+v[tree2[i]])) # dv
process model
        tau.dv[i] <- 1/(sd.dv[i]*sd.dv[i]) # conversion of sd to tau
        sd.dv[i] <- b[5]+b[6]*2*diam2[i] # predictive equation for sd as a function of the
diameter
                }
for (i in 1:Ntree2){ v[i]~dnorm(0, tau.v) } # Random term for b4
for (i in 1:6){ b[i]~dnorm(0,0.001) }  #Priors
        tau.v <- 1/(sd.v*sd.v)
        sd.v ~ dunif(0,100)


#Prediction at the stand-level using the application dataset
for(i in 1:Nplot3){
        for(j in 1:Ntree3[i]){
```

```
        # Sample random effects first at the tree level
                u1.new[i,j]~dnorm(0,tau.u[1])
                u2.new[i,j]~dnorm(0,tau.u[2])
                u3.new[i,j]~dnorm(0,tau.u[3])
                 v.new[i,j]~dnorm(0,tau.v)

for(k in 1:Nyear3){
        wd.new.nor[i,j,k]<- a[1] + a[2]*pow(RWnew[i,j,k],0.5) +
                              (a[3]/pow(Dnew[i,j,k],0.5))
  dv.new.nor[i,j,k]<- b[1] + b[2]*pow(Dnew[i,j,k], b[3])*pow(RWnew[i,j,k], b[4])

   # Realise prediction by inserting new predictors and u.new
        wd.new.par[i,j,k]<-  (a[1]+u1.new[i,j])  +  (a[2]+u2.new[i,j])*pow(RWnew[i,j,k],0.5)
+ (a[3]+u3.new[i,j])/pow(Dnew[i,j,k],0.5)
        dv.new.par[i,j,k]     <-     b[1]+b[2]*pow(Dnew[i,j,k],     b[3])*pow(RWnew[i,j,k],
b[4]+v.new[i,j])

        # Sample from residual distribution
        wd.new[i,j,k]~dnorm(wd.new.par[i,j,k], tau.wd)
        # Calculate new tau.dv (residual variance is modeled, not fixed)
        tau.dv.new[i,j,k] <- pow(b[5]+b[6]*Dnew[i,j,k],-2)
        dv.new[i,j,k] ~ dnorm(dv.new.par[i,j,k], tau.dv.new[i,j,k])

    # Multiplication to of WD and deltaV to obtain the biomass increments
        sc0[i,j,k] <- 475*dv.new.nor[i,j,k]
        sc1[i,j,k] <- 400*dv.new.nor[i,j,k]
        sc2[i,j,k] <- 400*dv.new[i,j,k]
        sc3[i,j,k] <- wd.new.nor[i,j,k]*dv.new.nor[i,j,k]
        sc4[i,j,k] <- wd.new[i,j,k]*dv.new[i,j,k]
}}}

#aggregated estimates at stand level
for(i in 1:Nplot3){
            for(k in 1:Nyear3){
                ssc0[i,k]<-sum(sc0[i,1:Ntree3[i],k])/areaplot[i]
                ssc1[i,k]<-sum(sc1[i,1:Ntree3[i],k])/areaplot[i]
                           ssc2[i,k]<-sum(sc2[i,1:Ntree3[i],k])/areaplot[i]
                           ssc3[i,k]<-sum(sc3[i,1:Ntree3[i],k])/areaplot[i]
                           ssc4[i,k]<-sum(sc4[i,1:Ntree3[i],k])/areaplot[i]
```

```
                }}
} # end model



#data:
list(   Ndata1=1243, Ntree1=12, # Wood density fit set
        Ndata2=1169, Ntree2=22,  # Stem analysis fit set
        Nplot3=13,    Ntree3=c(36,55,62,37,35,39,38,37,53,40,31,35,53),    Nyear3=10,    #
Application set
areaplot=c(678.58,678.58,1100,678.58,678.58,678.58,678.58,678.58,678.58,678.58,678.58,678
.58,1100)
```