Design notes for adding standing dead wood biomass pools to DayCent

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**New pools**

Add to new plot4.inc file along with new fluxes listed below (done).

* dleavc – carbon in attached dead leaf biomass (g C m-2)
* dleave(3) – N, P, S in attached dead leaf biomass (g E m-2)
* dlvcis(2) – unlabeled and labeled carbon in attached dead leaf biomass (g C m-2)
* dfbrchc – carbon in attached dead fine branch biomass (g C m-2)
* dfbrche(3) – N, P, S in attached dead fine branch biomass (g E m-2)
* dfbrcis(2) – unlabeled and labeled carbon in attached dead fine branch biomass (g C m-2)
* dlwodc – carbon in attached dead standing large wood biomass (g C m-2)
* dlwode(3) – N, P, S in attached dead standing large wood biomass (g E m-2)
* dlwcis(2) – unlabeled and labeled carbon in standing large wood biomass (g C m-2)

Aggregate pools

* dfrstc – total C in standing forest biomass (gC/m2)
* dfrste(3) – total N,P,S in standing forest biomass (gE/m2)

**New fluxes**

Add to cflows.inc (done)

* dwood1tosom11 - carbon flow from dead attached fine branches to active surface organic matter pool.
* dwood1tosom21 - carbon flow from dead attached fine branches to slow surface organic matter pool.
* dwood2tosom11 - carbon flow from dead standing large wood to active surface organic matter pool.
* dwood2tosom21 - carbon flow from dead standing large wood to slow surface organic matter pool.
* adwood1tosom11 - annual accumulator for the C flow from dead attached fine branches to active surface organic matter pool.
* adwood1tosom21 - annual accumulator for the C flow from dead attached fine branches to slow surface organic matter pool.
* adwood2tosom11 - annual accumulator for the C flow from dead standing large wood to active surface organic matter pool.
* adwood2tosom21 - annual accumulator for the C flow from dead standing large wood to slow surface organic matter pool.

Add to plot4.inc along with new pools listed above (done).

* dw1mnr(MAXIEL) - mineralization from the decomposition of attached dead fine branches (gE/m2/month)
* dw2mnr(MAXIEL) - mineralization from the decomposition of standing dead large wood (gE/m2/month)
* dwd1c2(ISOS) - heterotrophic respiration from the decomposition of attached dead fine branches (gCO2-C/m2/month)
* dwd2c2(ISOS) - heterotrophic respiration from the decomposition of standing dead large wood (gCO2-C/m2/month)
* wstduvc2(ISOS) – CO2 released when dead attached leaves undergo photodegradation (gCO2-C/m2/month)
* awstduvc2 – annual accumulator for CO2 released when dead attached leaves undergo photodegradation (gCO2-C/m2/yr)
* tcreta– annual accumulator of C returned to system as litter, dead surface wood, or charcoal during a TREM (tree removal) event for a forest/savanna system (g C m‑2yr‑1)
* tereta(3) – annual accumulator of N, P, S returned to system as litter, dead surface wood, or elemental return to mineral soil during a TREM (tree removal) event for a forest/savanna system (g E m‑2yr‑1)

Places in the code where these fluxes must be accumulated and written to output: savarp. simsom, mthacc, annacc.

Live counterparts:

rleavc, rleave(3), rlvcis(2), fbrchc, fbrche(3), fbrcis(2), rlwodc, rlwode(3), rlwcis(2)

Downed dead fine branches and large wood:

wood1c, wood1e(3), wd1cis(2), wood2c, wood2e(3), wd2cis(2)

**Files to be updated**

* sitein.f – read new site.100 parameters: dlvcis(2), dfbrcis(2), dlwcis(2) (done).
* sitein\_ext.f: dlvcis(2), dfbrcis(2), dlwcis(2), dleave(3), dfbrche(3), dlwode(3) (done).
  + wrtsitext.f dlvcis(2), dfbrcis(2), dlwcis(2), dleave(3), dfbrche(3), dlwode(3) (done).
* sitein\_grid.f dlvcis(2), dfbrcis(2), dlwcis(2), dleave(3), dfbrche(3), dlwode(3) (done).
  + is there a routine to write this file?
* calciv – initialize dleave(3), dfbrche(3), and dlwode(3) (done).
* treein.f – read tree.100 parameters (done)
* tremin.f – read trem.100 parameters (done)
* outvals.inc – a list of all binary output variables (so far have added 39 new variables to vals4 to the previous 111 from grasstree for a total of 150).
* default.f – initializes \*.100 values before they are read in (done: updated for plot4.inc, cflows.inc, forrem.inc, and parfs.inc).
* cutrn.f - returns harvested leaves and wood to surface litter and dead wood pools, respectively, after a cutting event. Include standing dead pools also (done).
* firrtn.f – charcoal and elemental return from a fire event. Wood1c and wood2c are not included here, but dead standing leaves, branches, and large wood will be (done).
* wdeath.f – death of trees. Add flows from aboveground live to standing dead (done).
* woodec.f – decomposition of dead wood. Include standing dead wood and attached dead fine branches. (done). Currently there is no decomposition of dead attached leaves aside from photodegradation.
* photodecomp.f – abiotic decomposition of standing dead crops and surface litter due to UV radiation. Add attached dead leaves (done).
* frem.f – this calls other forest removal subroutines when there is TREM event. Add calls to new subroutines stdedrem and killlv (done).
* sumcar.f – sums carbon pools and production accumulators (done).
* savarp.f – sums aggregate output variables (done)
* wrtdeadc.c – daily output of litter and dead wood biomass. Include standing dead wood and attached dead leaves. Also update file header in initsw.c and subroutine call in simsom.f (done).
* wrtcflows – daily cflows output. Include 4 dwood\* fluxes. Also update file header in initsw.c and subroutine call in dailymoist.f (done).
* wrtyrcflows – annual cflows output. Include 4 adwood\* accumulators. Also update file header in initsw.c and subroutine call in csa\_main.f (done).
* parfs.inc – add new tree.100 parameters (done).
* forrem.inc – add new trem.100 parameters (done).

**New files (done)**

* wfalstd.f – fall of attached dead leaves and standing dead wood from non-disturbances (done).
* stdedrem.f – removal of dleavc, dfrbchc, and dlwodc during TREM cutting or burning event (done)
* killlv.f – transfer live rleavc, frbchc, and rlwodc to standing dead dleavc, dfrbchc, and dlwodc during TREM cutting or fire event (done).
* plot4.inc – add new variables to plot4.inc (this file also has grasstree output variables for eventually merger with that code) (done).

**Order of operations for TREM and FIRE events**

Pre-snag

* Call livrem – removes live above-ground tree biomass during TREM cutting or burning event.
* Call killrt – kills live tree roots during TREM cutting or burning event.
* Call dedrem – removes surface dead wood (wood1c and wood2c) during TREM cutting event.
* Call cutrn – returns harvested leaves and wood to surface litter and dead wood pools during TREM cutting event.
* Call firrtn – returns charcoal to som3c and N,P,S to the surface mineral pools during TREM burning event.
* Call grem – burns surface litter and surface dead wood during FIRE event.

Snag updates (done)

* Call livrem – removes live above-ground tree biomass during TREM cutting or burning event.
* Call stdedrem - removes dleavc, dfrbchc, and dlwodc during TREM cutting or burning event.
* Call killlv – transfer live rleavc, frbchc, and rlwodc to standing dead dleavc, dfrbchc, and dlwodc during TREM cutting or burning event.
* Call killrt – kills live tree roots during TREM cutting or burning event.
* Call dedrem – removes surface dead wood (wood1c and wood2c) during TREM cutting event.
* Call cutrn – returns harvested leaves and wood to surface litter and dead wood pools during TREM cutting event.
* Call firrtn – returns charcoal to som3c and N,P,S to the surface mineral pools during TREM burning event
* Call grem – burns surface litter and surface dead wood during FIRE event.

**New site.100 parameters (initial pool values when not extending from a binary file)**

* dlvcis(2) – unlabeled and labeled carbon in attached dead leaf biomass (g C m-2)
* dfbrcis (2) – unlabeled and labeled carbon in attached dead fine branch biomass (g C m-2)
* dlwcis (2) – unlabeled and labeled carbon in standing large wood biomass (g C m-2)

Initial elemental pool values are determined using the maximum C:E ratios of leaves and wood and are not included in the site.100 file:

* ~~dleave(1-3) – N, P, S in attached dead leaf biomass (g E m~~~~-2~~~~)~~
* ~~dfbrche(1-3) – N, P, S in attached dead fine branch biomass (g E m~~~~-2~~~~)~~
* ~~dlwode(1-3) – N, P, S in attached dead standing large wood biomass (g E m~~~~-2~~~~)~~

**New tree.100 parameters (add to parfs.inc)**

* dlvfalrt - fall rate of dead attached leaves (fraction per month, in absence of disturbance)
* dfbfalrt - fall rate of dead attached branches (fraction per month, in absence of disturbance)
* dlwfalrt - fall rate of dead standing large wood (fraction per month, in absence of disturbance)
* decw4 - maximum decomposition rate constant for attached dead fine branches per year before temperature and moisture effects (same as soil surface) are applied (year-1). (See woodec.f)
* decw5 - maximum decomposition rate constant for standing dead large wood per year before temperature and moisture effects (same as soil surface) are applied (year-1). (See woodec.f)

**Pool transfers**

* Transfer of live leaves to dead attached leaves
  + (rlvcis 🡪 dlvcis; rleave🡪 dleave)
* Transfer of live leaves to surface litter
  + (rlvcis 🡪 strcis and metcis; rleave🡪 struce and metabe)
* Transfer of dead attached leaves to surface litter
  + (dlvcis 🡪 strcis and metcis; dleave🡪 struce and metabe)
* Transfer of live fine branches to dead attached fine branches
  + (fbrcis 🡪 dfbrcis, fbrche 🡪 dfbrche)
* Transfer of live fine branches to downed dead branches
  + (fbrcis 🡪 wood1c; fbrche 🡪 wood1e)
* Transfer of dead attached fine branches to downed dead branches
  + (dfbrcis 🡪 wood1c; dfbrche 🡪 wood1e)
* Transfer of live large wood to dead standing large wood
  + (rlwcis🡪 dlwcis, rlwode🡪 dlwode)
* Transfer of live large wood to downed large wood
  + (rlwcis🡪 wd2cis, rlwode🡪 wood2e)
* Transfer of dead standing large wood to downed large wood
  + (dlwcis🡪 wd2cis, dlwode🡪 wood2e)

**Other considerations (not all have been addressed yet as of 10/26/2018)**

* Existing tree harvest and removal accumulators are tcrem, terem(3). These accumulators will include all live and dead wood removed. Currently these accumulators are not reduced by the amount of charcoal and elements returned to the system.
* Make sure to update fire.100 parameter definitions so it is clear they do not include standing dead wood.
* What are the moisture and temperature effects on the decomposition of standing dead wood? I used the soil surface effects (agdefac) for now.
* Dead attached fine branches could be attached to either dead or live large live wood, and dead attached leaves could be attached to either dead or live attached fine branches or large wood)
  + When all live and dead fine branches are removed, should all attached leaves be removed? This check is not currently being done.
  + When all live standing ?AND? dead wood is removed, should all live and dead attached fine branches and attached leaves be removed? This check is not currently being done.
* How do dead attached leaves decompose aside from photodegradation?

**Updated list of trem.100 parameters. New parameters are in green. Updated definitions of existing parameters are highlighted in yellow.**

|  |  |  |  |
| --- | --- | --- | --- |
| evntyp | Event type flag  = 0 for cutting, pruning, windstorm, or other non-fire event  = 1 for fire | index | 0,1 |
| remf(1) | Fraction of live leaves (rleavc) that is KILLED in the event. The fraction 1.0 – lv2std(1) determines how much is removed by cutting or fire. | fraction | 0.0 – 1.0 |
| remf(2) | Fraction of live fine branches (fbrchc) that is KILLED in the event. The fraction 1.0 – lv2std(2) determines how much is removed by cutting or fire. | fraction | 0.0 – 1.0 |
| remf(3) | Fraction of live large wood (rlwodc) that is KILLED in the event. The fraction 1.0 – lv2std(3) determines how much is removed by cutting or fire. | fraction | 0.0 – 1.0 |
| remf(4) | Fraction of dead fine branches on the ground (wood1c) that is removed. This parameter applies to non-fire events only. To burn dead fine branches on the surface one must schedule a FIRE event; see fire.100 parameters. | fraction | 0.0 – 1.0 |
| remf(5) | Fraction of dead large wood on the ground (wood2c) that is removed. This parameter applies to non-fire events only. To burn dead large wood on the surface one must schedule a FIRE event; see fire.100 parameters. | fraction | 0.0 – 1.0 |
| remf(6) | Fraction of existing dead attached leaves (dleavc) that is removed in the event. | fraction | 0.0 – 1.0 |
| remf(7) | Fraction of existing dead attached fine branches (dfbrchc) that is removed in the event. | fraction | 0.0 – 1.0 |
| remf (8) | Fraction of existing dead standing large wood (dlwodc) that is removed in the event. | fraction | 0.0 – 1.0 |
| fd(1) | Fraction of fine root components that die. | fraction | 0.0 – 1.0 |
| fd(2) | Fraction of coarse root components that die. | fraction | 0.0 – 1.0 |
| retf(1,1) | Fraction of C in removed live leaves (those not transferred to dead attached leaf pool) that is returned to the system (ash or litter). | fraction | 0.0 – 1.0 |
| retf(1,2) | Fraction of N in removed live leaves (those not transferred to dead attached leaf pool) that is returned to the system (ash or litter). | fraction | 0.0 – 1.0 |
| retf(1,3) | Fraction of P in removed live leaves (those not transferred to dead attached leaf pool) that is returned to the system (ash or litter). | fraction | 0.0 – 1.0 |
| retf(1,4) | Fraction of S in removed live leaves (those not transferred to dead attached leaf pool) that is returned to the system (ash or litter). | fraction | 0.0 – 1.0 |
| retf(2,1) | Fraction of C in removed live fine branches (those not transferred to dead attached fine branch pool) that is returned to the system (ash or dead fine branches). | fraction | 0.0 – 1.0 |
| retf(2,2) | Fraction of N in removed from live fine branches (those not transferred to dead attached fine branch pool) that is returned to the system (ash or dead fine branches). | fraction | 0.0 – 1.0 |
| retf(2,3) | Fraction of P in removed live fine branches (those not transferred to dead attached fine branch pool) that is returned to the system (ash or dead fine branches). | fraction | 0.0 – 1.0 |
| retf(2,4) | Fraction of S in removed live fine branches (those not transferred to dead attached fine branch pool) that is returned to the system (ash or dead fine branches). | fraction | 0.0 – 1.0 |
| retf(3,1) | Fraction of C in removed live large wood (the portion not transferred to standing dead large wood pool) that is returned to the system (ash or dead large wood). | fraction | 0.0 – 1.0 |
| retf(3,2) | Fraction of N in removed live large wood (the portion not transferred to standing dead large wood pool) that is returned to the system (ash or dead large wood). | fraction | 0.0 – 1.0 |
| retf(3,3) | Fraction of P in removed live large wood (the portion not transferred to standing dead large wood pool) that is returned to the system (ash or dead large wood). | fraction | 0.0 – 1.0 |
| retf(3,4) | Fraction of S in removed live large wood (the portion not transferred to standing dead large wood pool) that is returned to the system (ash or dead large wood). | fraction | 0.0 – 1.0 |
| retf(4,1) | Fraction of C in removed dead attached leaves that is returned to the system (ash or litter). | fraction | 0.0 – 1.0 |
| retf(4,2) | Fraction of N in removed dead attached leaves that is returned to the system (ash or litter). | fraction | 0.0 – 1.0 |
| retf(4,3) | Fraction of P in removed dead attached leaves that is returned to the system (ash or litter). | fraction | 0.0 – 1.0 |
| retf(4,4) | Fraction of S in removed dead attached leaves that is returned to the system (ash or litter). | fraction | 0.0 – 1.0 |
| retf(5,1) | Fraction of C in removed dead attached fine branches that is returned to the system (ash or dead fine branches). | fraction | 0.0 – 1.0 |
| retf(5,2) | Fraction of N in removed dead attached fine branches that is returned to the system (ash or dead fine branches). | fraction | 0.0 – 1.0 |
| retf(5,3) | Fraction of P in removed dead attached fine branches that is returned to the system (ash or dead fine branches). | fraction | 0.0 – 1.0 |
| retf(5,4) | Fraction of S in removed dead attached fine branches that is returned to the system (ash or dead fine branches). | fraction | 0.0 – 1.0 |
| retf(6,1) | Fraction of C in removed standing dead large wood that is returned to the system (ash or dead large wood). | fraction | 0.0 – 1.0 |
| retf(6,2) | Fraction of N in removed standing dead large wood that is returned to the system (ash or dead large wood). | fraction | 0.0 – 1.0 |
| retf(6,3) | Fraction of P in removed standing dead large wood that is returned to the system (ash or dead large wood). | fraction | 0.0 – 1.0 |
| retf(6,4) | Fraction of S in removed standing dead large wood that is returned to the system (ash or dead large wood). | fraction | 0.0 – 1.0 |
| lv2std(1) | Fraction of killed live leaves that is transferred to dead attached leaves. (The fraction 1.0 – lv2std(1) is what gets removed). If event type is a fire then it is assumed that this transfer only killed the leaves but did not burn them. | fraction | 0.0 – 1.0 |
| lv2std(2) | Fraction of killed fine branches that is transferred to dead attached fine branches. (The fraction 1.0 – lv2std(2) is what gets removed). If event type is a fire then it is assumed that this transfer only killed the branches but did not burn them. | fraction | 0.0 – 1.0 |
| lv2std(3) | Fraction of killed live large wood that is transferred to dead standing large wood. (The fraction 1.0 – lv2std(3) is what gets removed). If event type is a fire then it is assumed that this transfer only killed the large wood but did not burn it. | fraction | 0.0 – 1.0 |

**Modifications to wood death (wdeath) subroutine:**

This will be immediately followed by call to subroutine wfalstd.

* When evergreen leaves die, these leaves get transferred into the dead attached leaf pool (instead of going directly to surface litter). Therefore, the fallrate of dead attached leaves (DLVFALRT) should be > 0.0 so that leaf N gets recycled into the soil.
* When deciduous leaves die, these leaves get transferred to surface litter (as currently implemented)
* Any live fine branches that die are transferred to the attached dead fine branch pool (instead of to wood1c).
* Any live large wood that dies is transferred to the standing dead large wood pool (instead of to wood2c).

**New subroutine: fall of standing dead wood (wfalstd).**

This will be called after subroutine wdeath.

* Dead attached leaves are transferred to surface litter based on their fall rate (dlvfalrt)
  + (dlvcis 🡪 strcis and metcis; dleave🡪 struce and metabe)
* Dead attached fine branches are transferred to wood1c based on their fall rate (dfbfalrt)
  + (dfbrcis 🡪 wood1c; dfbrche 🡪 wood1e)
* Dead standing large wood is transferred to wood2c based on that fall rate (dlwfalrt)
  + (dlwcis🡪 wd2cis, dlwode🡪 wood2e)

**Updates to subroutine sumcar (sum carbon variables)**

dleavc = dlvcis(1) + dlvcis(2)

dfbrchc = dfbrcis(1) + dfbrcis(2)

dlwodc = dlwcis(1) + dlwcis(2)

**Updates to subroutine savarp (save output variables)**

New output variables dfrstc and dfrste(3) (add to plot4.inc)

dfrstc = dleavc + dfbrchc + dlwodc

fsysc = somtc + woodc + frstc + dfrstc + strucc(SRFC) + metabc(SRFC) +

& som1c(SRFC) + som2c(SRFC)

dfrste(iel) = dleave(iel) + dfbrche(iel) + dlwode(iel)

fsyse(iel) = somte(iel) + woode(iel) + frste(iel) + dfrste(iel)

& struce(SRFC,iel) + metabe(SRFC,iel) +

& som1e(SRFC,iel) + som2e(SRFC,iel)

totalc = somtc + strucc(SRFC) + metabc(SRFC) +

& som1c(SRFC) + som2c(SRFC) +

& aglivc + stdedc + bglivcj + bglivcm +

& csrsnk(UNLABL) + csrsnk(LABELD) + woodc + frstc + dfrstc

totale(iel) = tminrl(iel) + somte(iel) + struce(SRFC,iel) +

& metabe(SRFC,iel) + som1e(SRFC,iel) +

& som2e(SRFC,iel) + aglive(iel) + stdede(iel) +

& bglivej(iel) + bglivem(iel) + esrsnk(iel) +

& minerl(nll,iel) + parent(iel) + secndy(iel) +

& woode(iel) + frste(iel) + dfrste(iel) + crpstg(iel) +

& forstg(iel)