Woody decomposition in Irish forest ecosystems

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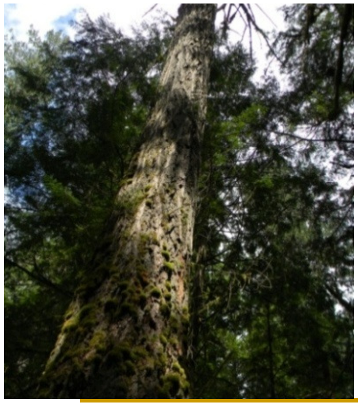
General Overview

1. Introduction
2. CWD stocks and decay dynamics in Sitka spruce forest
3. Thinning and soil respiratory C loss
4. Respiratory C loss from decaying logs
5. Belowground decomposition

Introduction

Coarse Woody Debris (CWD or deadwood)

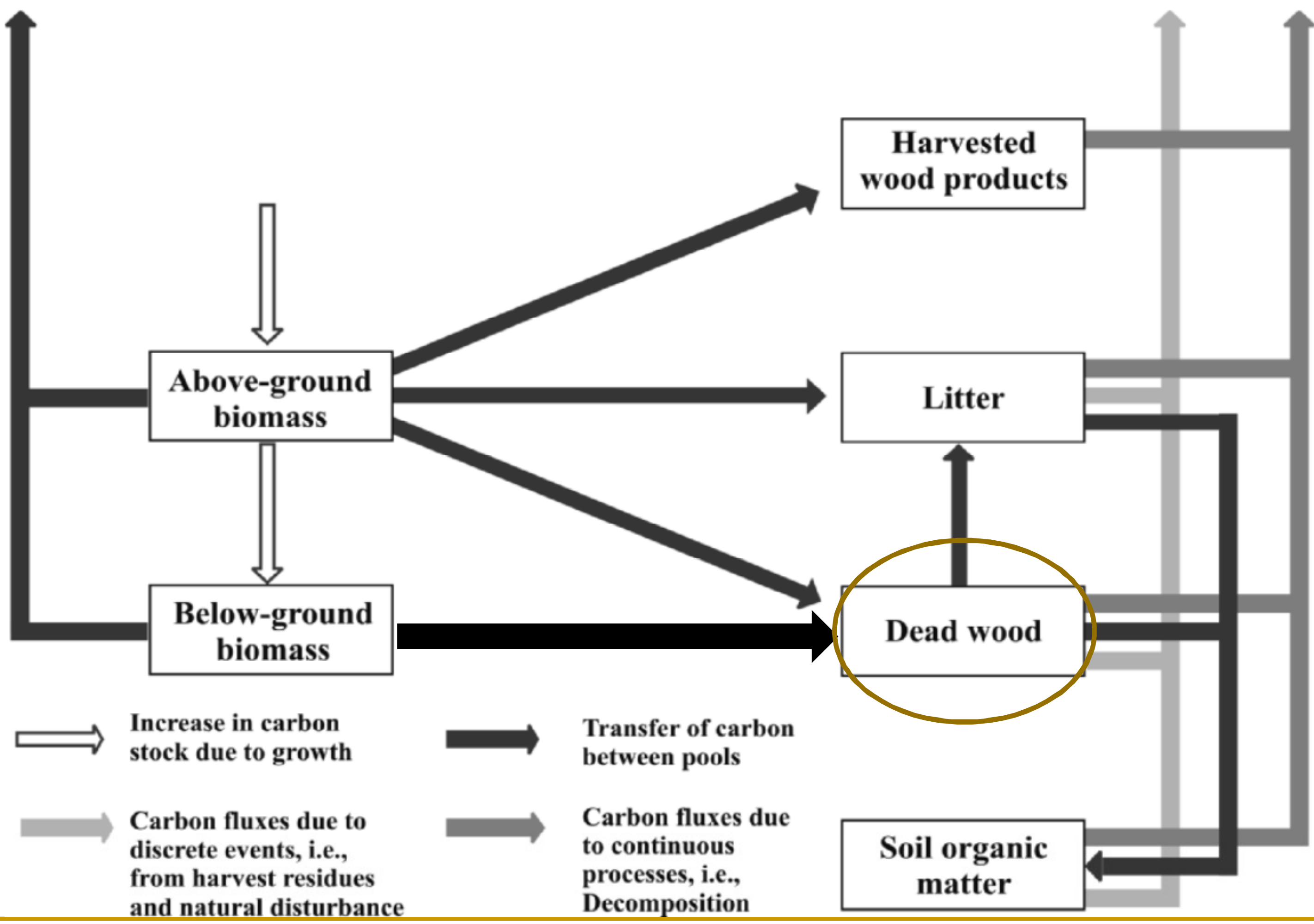
- Non-living woody biomass not contained in the litter pool;
  - Aboveground (snags or dead trees, logs ≥ 7cm in diameter and stumps)
  - Belowground (coarse roots > 2mm in diameter)




Role of Woody debris in forests

- Structural and functional component
  - Productivity of forests
  - Nutrient sink or source
  - Habitat and maintenance of biodiversity
  - Role in geomorphology of forests (e.g. soil protection, erosion control)
  - Long lived carbon (C) pool
  - Requirement for forest C reporting to UNFCCC and the Kyoto Protocol

Forest carbon (C) pools and pathways of C flow (IPCC 2006)

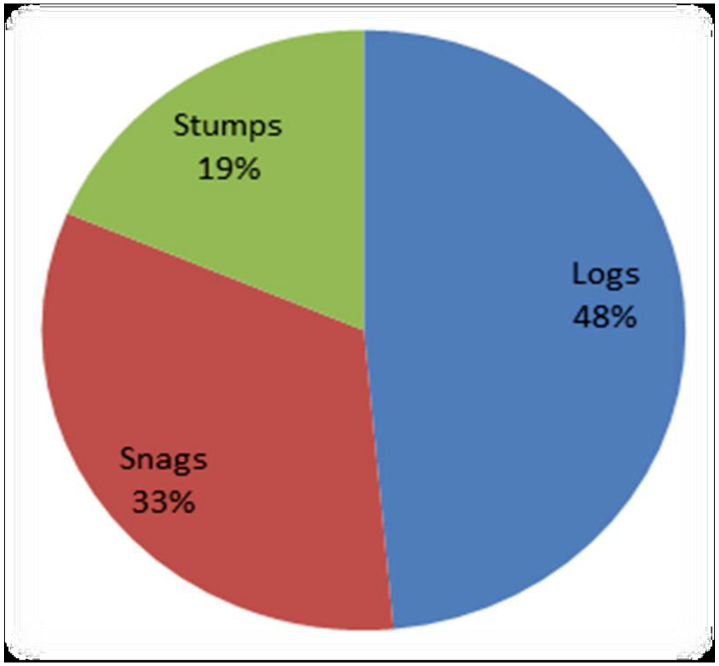


Decomposition process

- The mineralization and loss of C from CWD through bio-physical processes
  - Biological respiration
  - Biological transformation
  - Fragmentation
  - Leaching
  - Weathering

Sitka spruce in Ireland

- Sitka spruce
  - Most widely planted
  - Commercial tree species
  - Accounts for 52.3% of total forest estate



- Deadwood occurs in 45% of Irish forest (20.1 m^3 ha^{-1})

- Juvenile forest 59.7%
  - Disturbances (wind throws, harvesting etc)

Importance of CWD to managed Irish forests

- Stocks, decomposition rate and residence time of CWD have management implications :
  - for C storage,
  - soil strength,
  - belowground habitat,
  - biodiversity and nutrient dynamics,
  - essential for C reporting

1. CWD stocks and decay dynamics in Sitka spruce forest

- Volume and C stocks of CWD in stands at different management stages

- Influence of site age and thinning history

- Relate parameters used for measuring decay (density loss and C:N ratio)

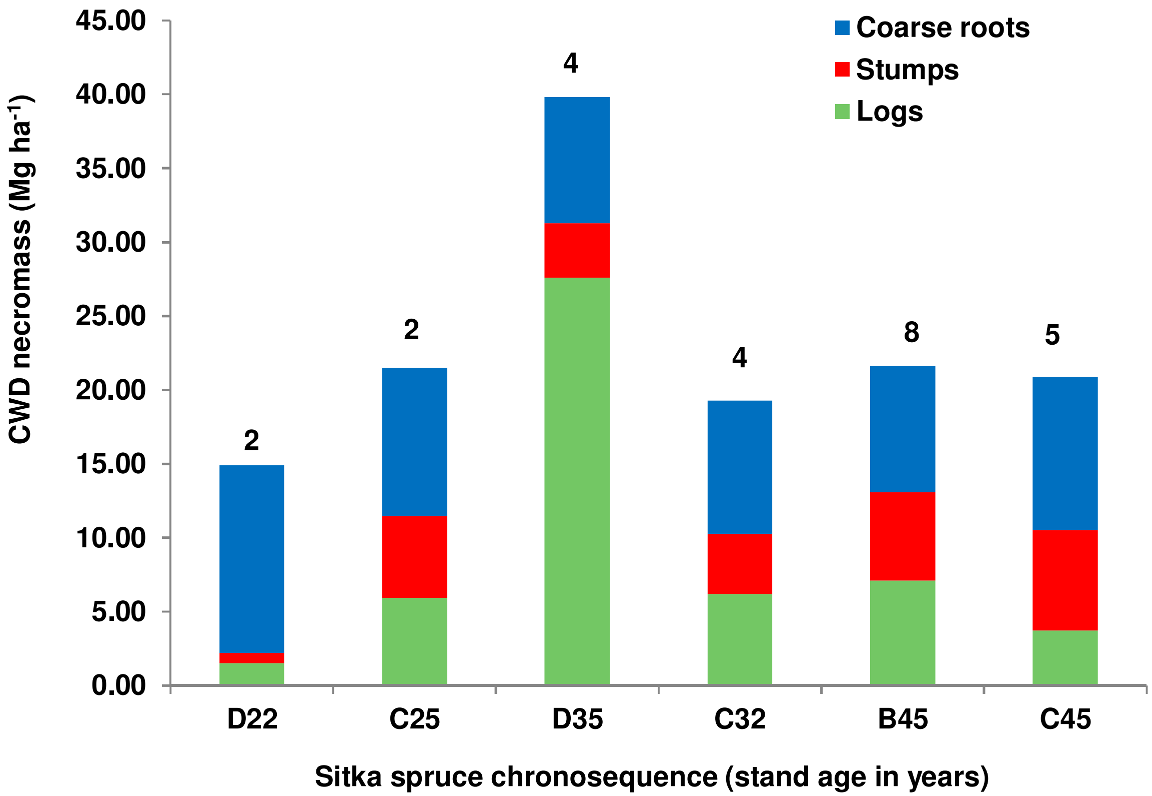
- Estimate decay rates for logs, stumps and coarse roots using decay curves

1. Methods

Chronosequence approach (young, intermediate and mature forests)

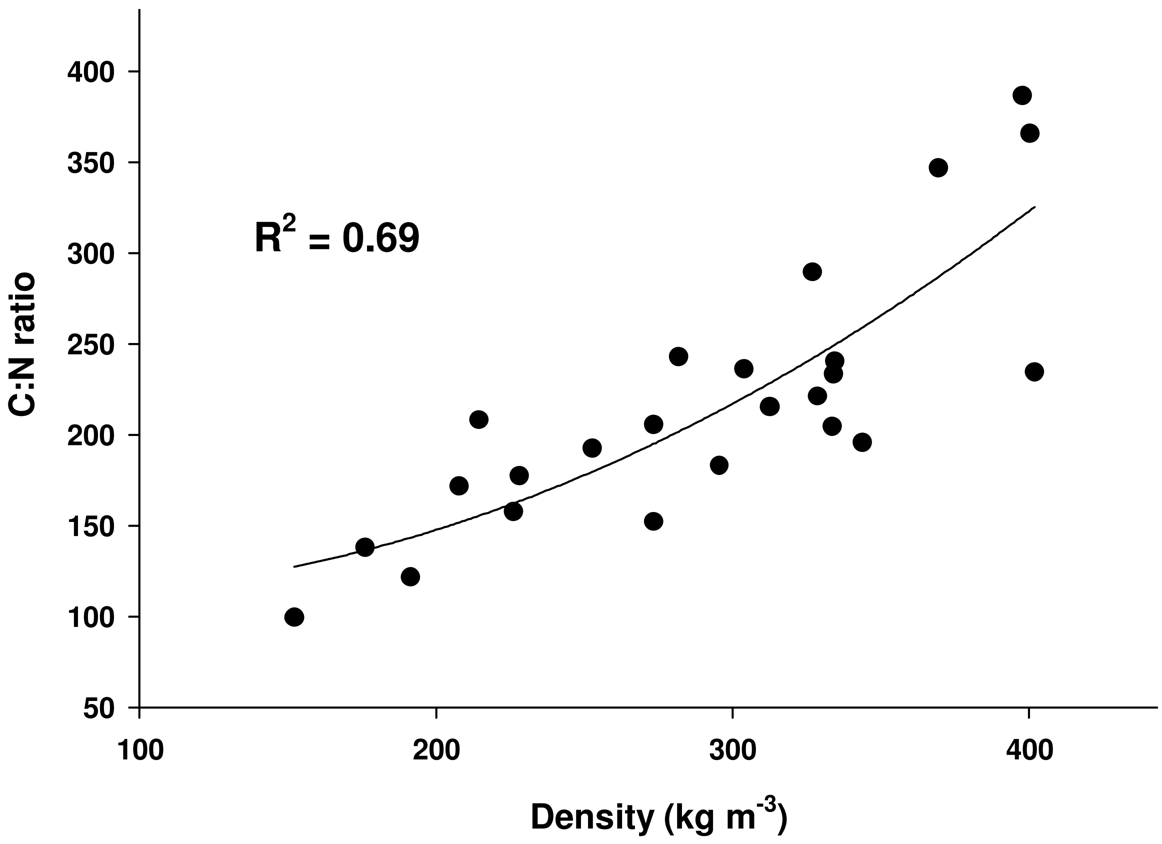
- Fixed area sample plots
- Decay classification (DC)
- Stump-root system decay class excavation
- Density determination
- C:N Analysis

1. CWD stocks



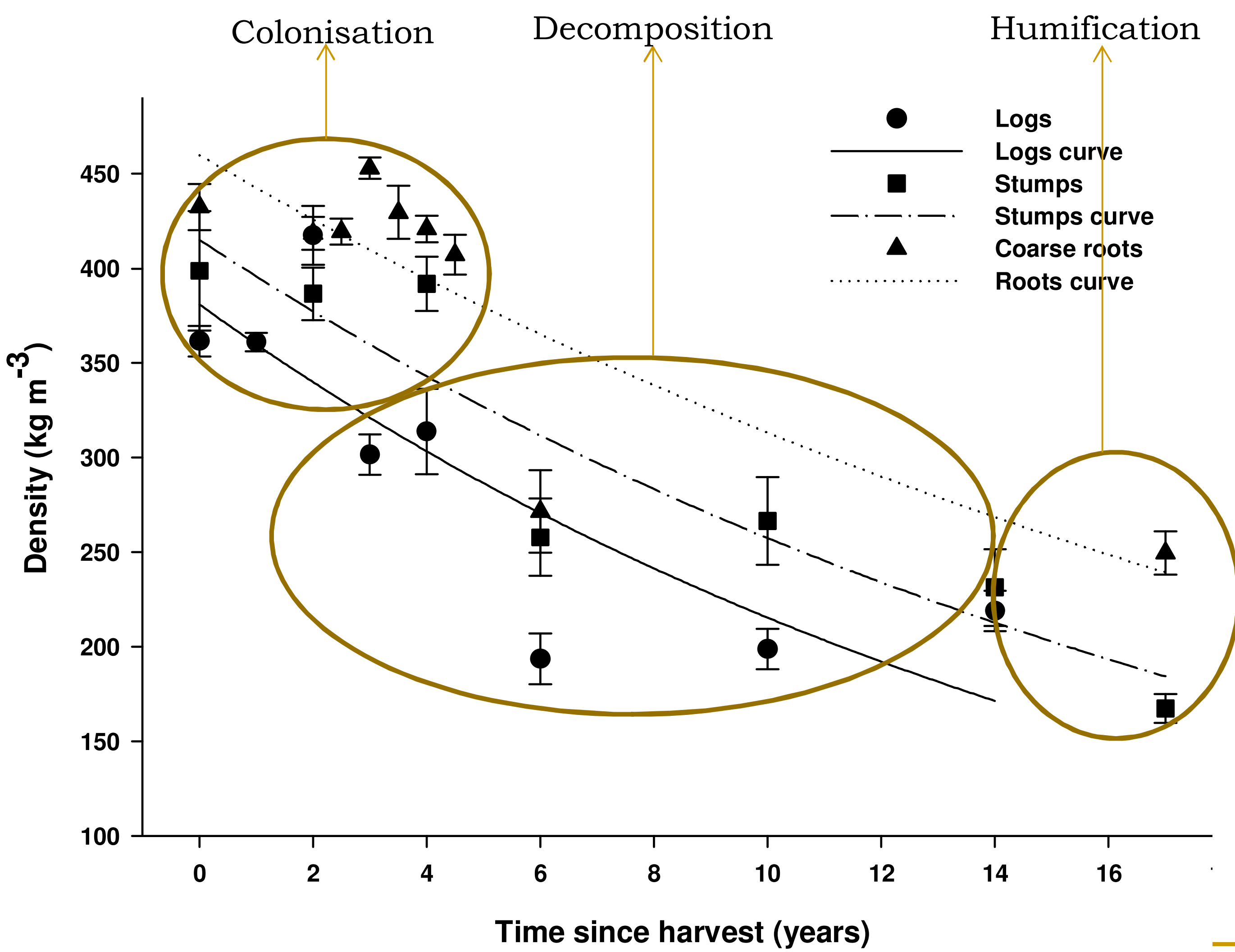
- Coarse roots contribute significantly to CWD stocks (21 -85%)
- Stand age and number of thinnings did not influence stocks
- CWD volume estimates ranged from 6.27 – 42.27m^3 ha^{-1}

1. Density loss and C:N ratio change in decaying logs



- Density is a physical measure of decay
- C:N ratio change can be used as an indicator of the stage of decay.

1. Density Decay Curves



Logs (0.059 $year^{-1}$)
Stumps (0.048 $year^{-1}$)
Roots (0.036 $year^{-1}$)

Decomposition occurs in 3 phases

1. Conclusions

- CWD stocks are significant long term C sinks high in managed Sitka spruce forests
  - **(Half life (50% decay) is 12-, 14- and 19-years for logs, stumps and coarse roots, respectively)**

- CWD input and volume is more dependent on operators efficiency and site productivity and quality than thinning history and age

- Inclusion of stumps with top diameter < 20 cm and logs with length < 1 m could increase national CWD estimates (20.1 m^3 ha^{-1})

- A more comprehensive DC system is encouraged for national CWD inventory
  - C:N ratio change is a good indicator of the stage of decay

Publication

Samuel O. Olajuyigbe, Brian Tobin, Paul Gardiner, Maarten Nieuwenhuis, M. 2011. Stocks and decay dynamics of above- and belowground coarse woody debris in managed Sitka spruce forests in Ireland. *Forest Ecology and Management* 262, 1109-1118.

http://dx.doi.org/10.1016/j.foreco.2011.06.010

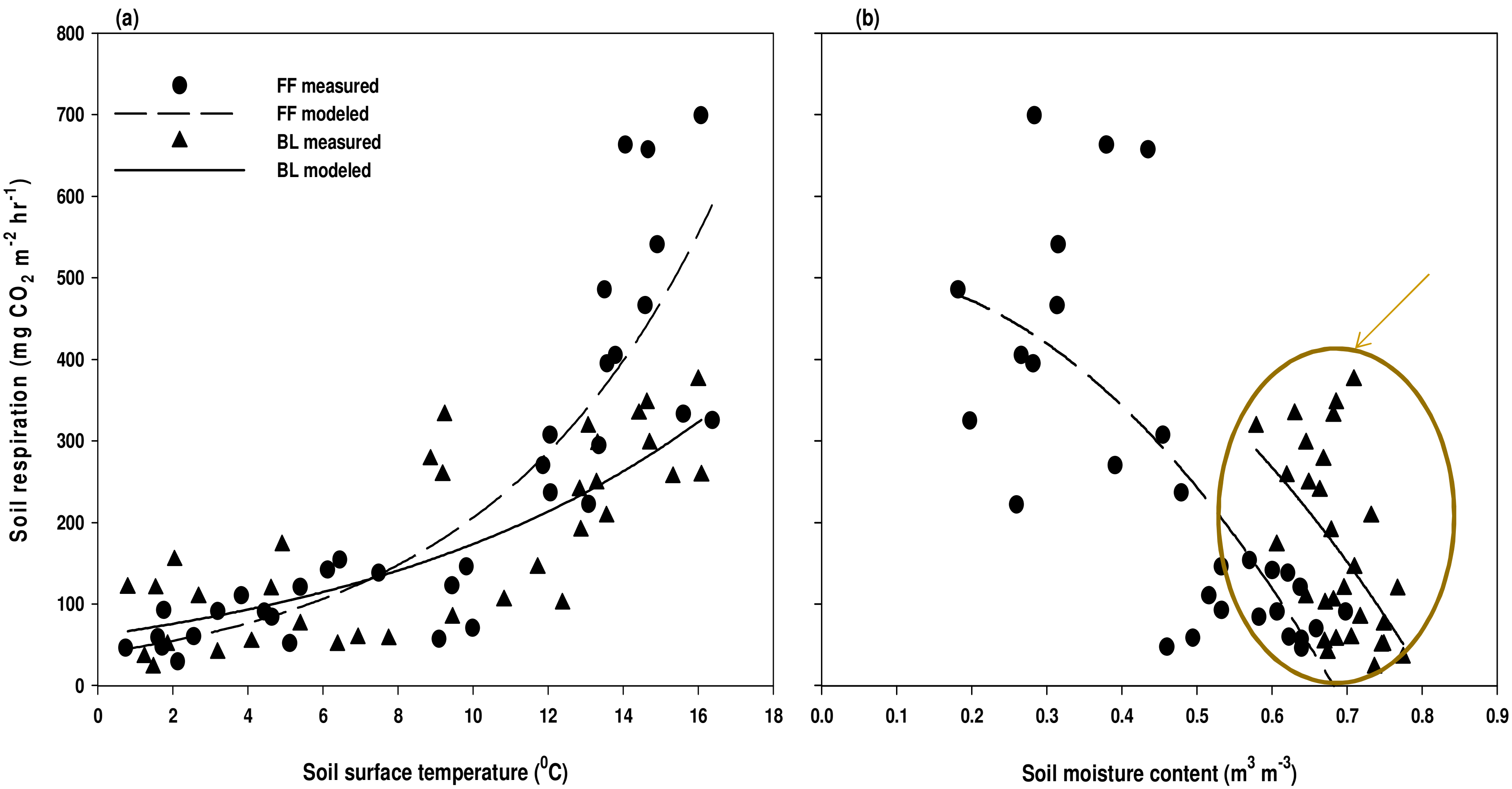
2. Thinning and soil respiratory C loss

- Impact of thinning on CO_2 respired from forest floor
- Influence of seasonal change in soil temperature and moisture on soil CO_2 efflux
- Relate gross primary productivity (GPP) to soil respiration
- Estimate annual soil C loss

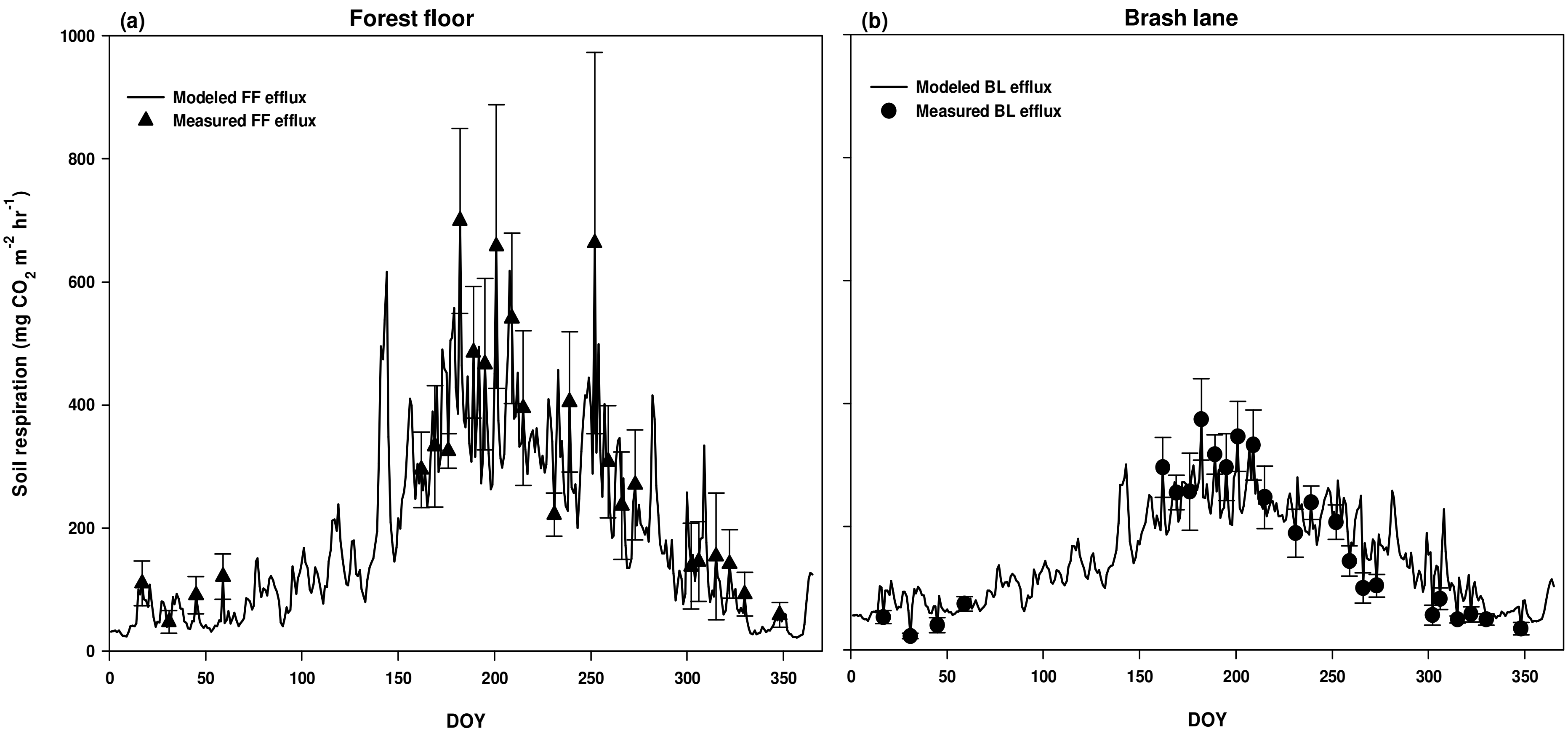
2. Methods

- Inserted steel collars in brash lanes (BL) and forest floor (FF) of thinned Sitka spruce forest
- Static chamber CO_2 measurements
- Soil moisture and soil surface temperature
- Compared soil respiration with gross primary productivity

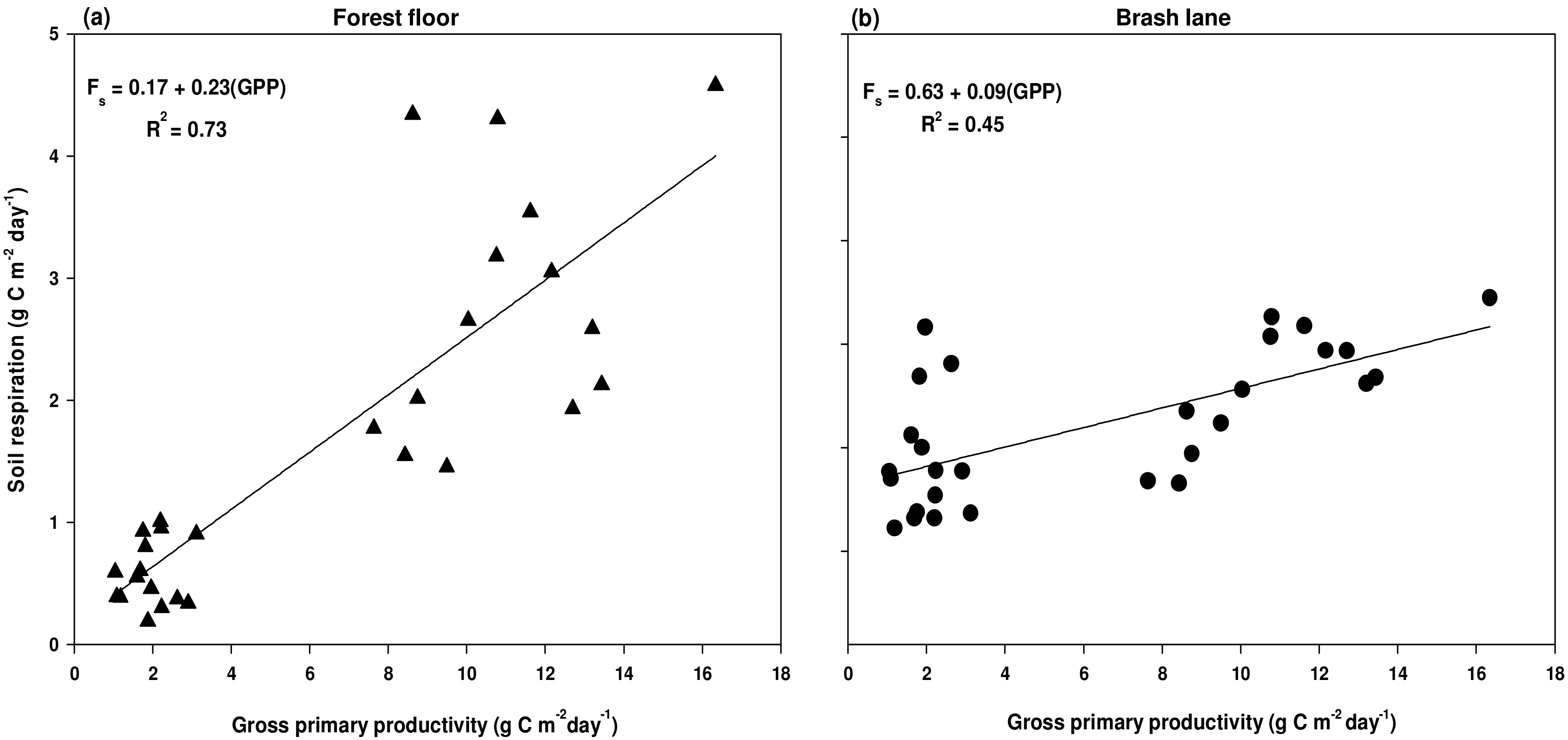
2. Temperature and moisture effects on soil respiration



2. CO_2 efflux from thinned Sitka spruce forest



Plant productivity and soil respiration



2. Conclusions

- Thinning residues did not significantly alter the soil respiration rate of the forest (reduces respiration by 3%)
- Annual soil respiratory C loss (4.35 t C ha^{-1}) represents 40% of total ecosystem respiration
- Seasonal change in soil temperature and moisture significantly drive soil CO_2 efflux
- Plant productivity is positively correlated with soil C loss

2. Publication

Samuel Olajuyigbe, Brian Tobin, Matthew Saunders, Maarten Nieuwenhuis, 2012. Forest thinning and soil respiration in a Sitka spruce forest in Ireland. *Agricultural and Forest Meteorology* 157, 86-95.

http://dx.doi.org/10.1016/j.agrformet.2012.01.016

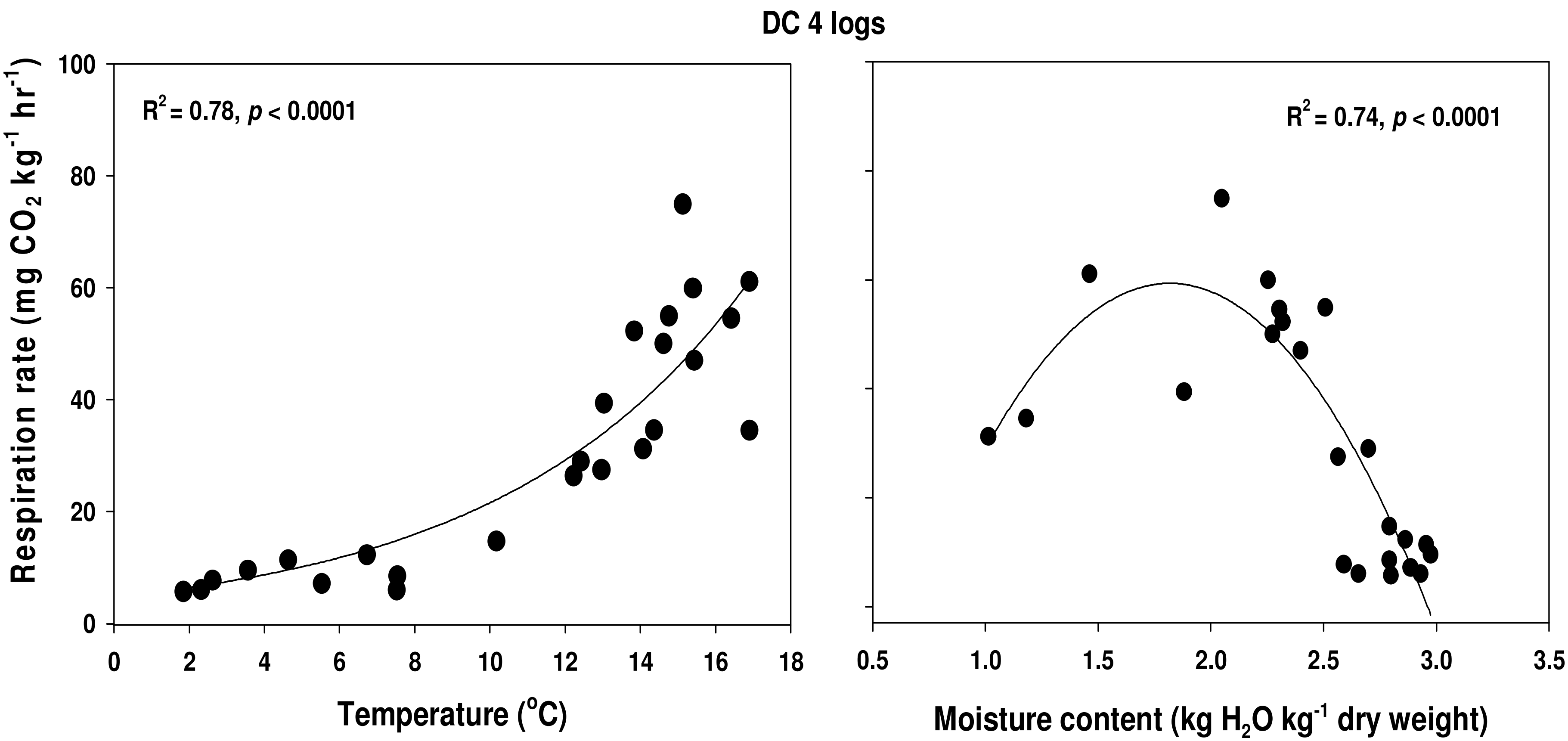
3. Respiratory C loss from decaying logs

- Determine decay rates of logs from decomposition derived CO_2 efflux
- Identify the significance of decay classification on the respiration rate of logs
- Determine the influence of temperature and moisture on C loss from logs

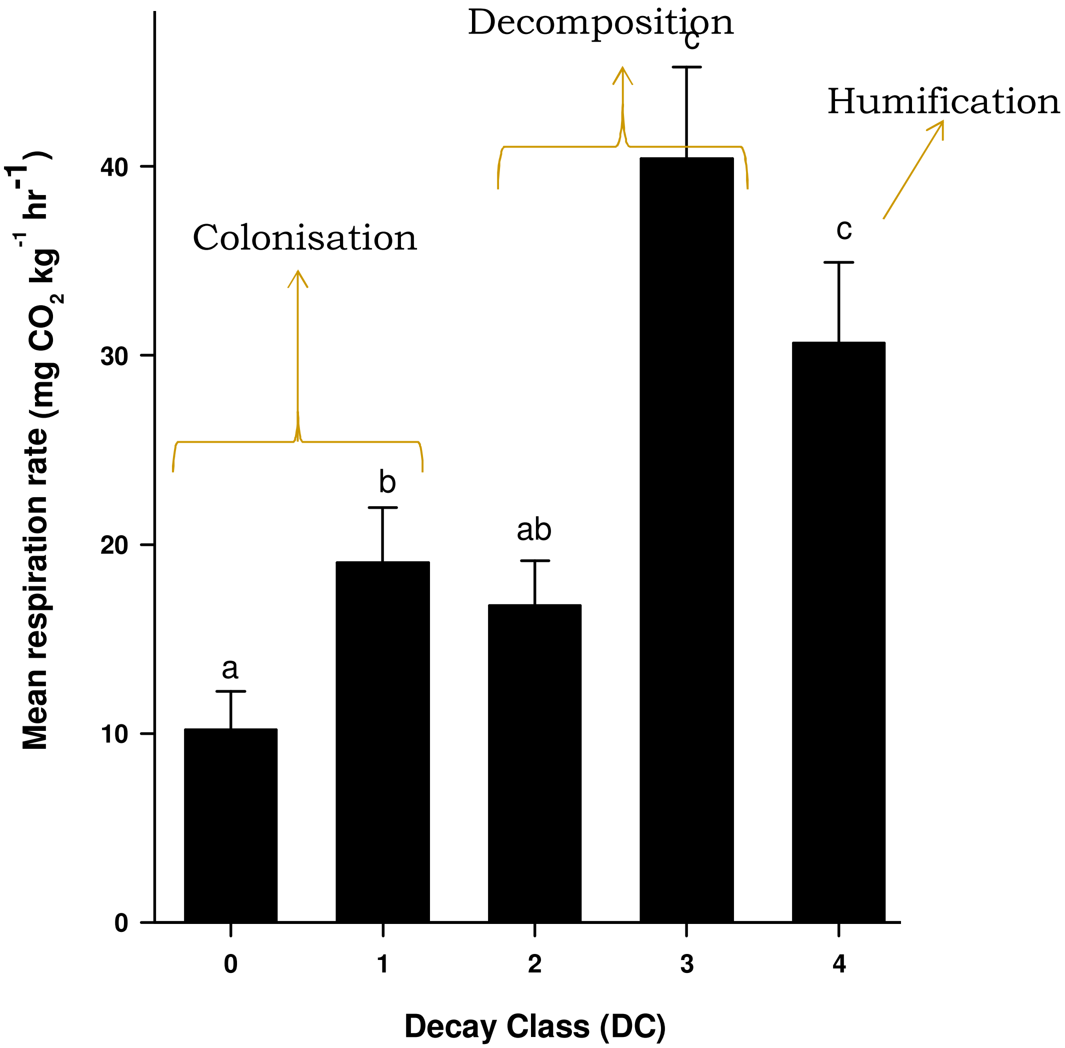
3. Methods

- Logs in different DC inserted into mesh bags
- Logs placed on the forest floor
- Weekly measurements of respiration rate of logs
- Measure moisture content and temperature

3. Temperature and moisture effects on decomposing CWD logs



3. Log decomposition phase



3. Conclusions

- Respiration derived decay rate for DC 3 (0.063 $year^{-1}$) compare with density decay rate (0.059 $year^{-1}$) for logs
- Average half life (50% decomposition) based on CO_2 release is 20 years
- Seasonal variation of temperature and moisture are main drivers of decomposition derived CO_2 efflux from logs
- These factors have limiting effects on each other

3. Publication

Olajuyigbe, S., Tobin, B., Nieuwenhuis, M. 2012. Temperature and moisture effects on respiration rate of decomposing logs in a Sitka spruce plantation in Ireland. *Forestry*

doi: 10.1093/forestry/CPS045

4. Root decomposition

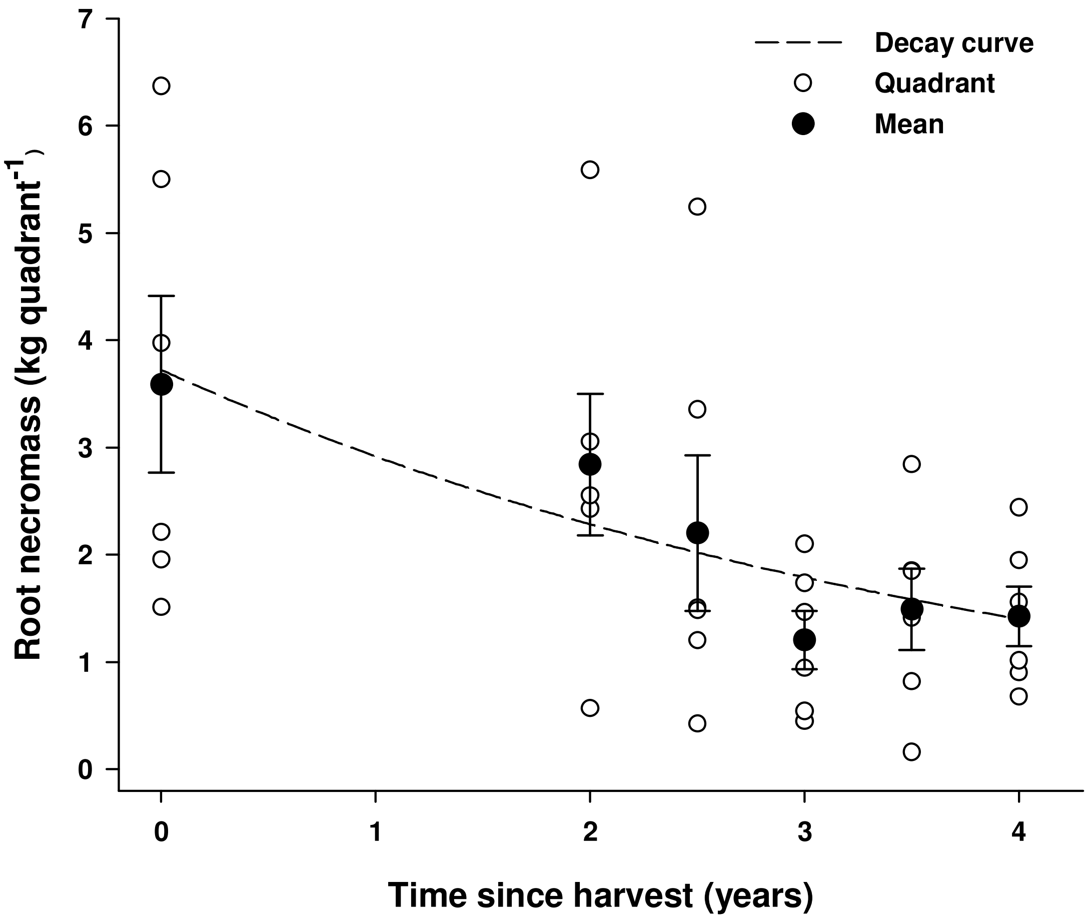
- Determine early stage decay rate of Sitka spruce roots
- Influence of root diameter on decomposition
- Use change in N content of decaying roots as an indicator of the stage of decay

4. Methods

- A. Trenched plot approach
  - Stumps in 6 brash lanes
  - 6-monthly excavation of randomly selected quadrants
  - Change in root mass/quadrant
  - C:N analysis of excavated root samples

- B. Buried root bags
  - (fine: < 2mm, small: 2-10mm, medium:10-50mm, large: >50mm)
  - Mass loss after 27 months

Trenched plots root excavation



- C = 5.94 Mg C ha^{-1}
- N = 0.08 Mg C ha^{-1}
- Decay rate was root diameter dependent

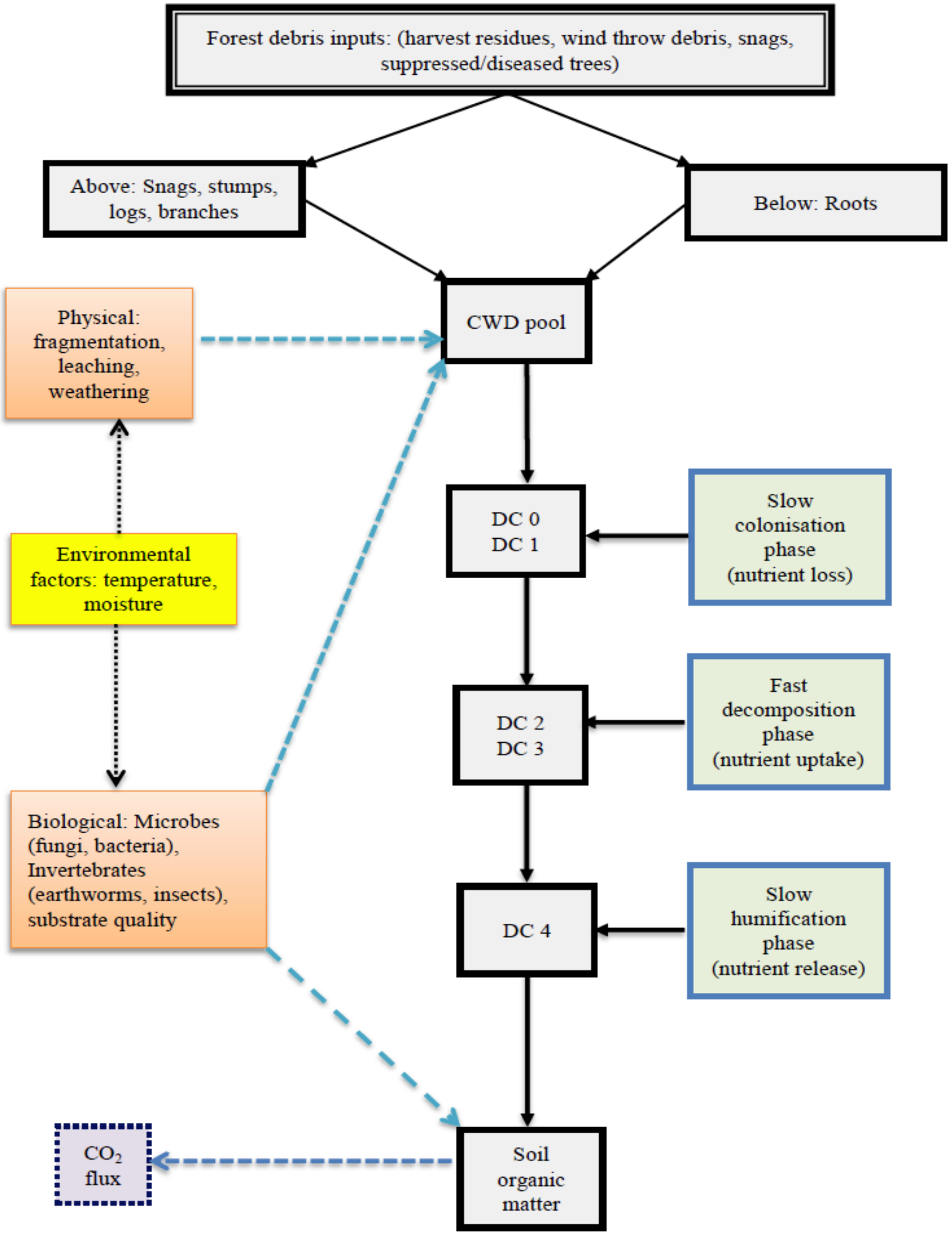
4. Conclusions

- Dead roots represent a significant C sink in managed forest (e.g. 5.94 Mg C ha^{-1})
- Decaying roots may serve as a N source and sink as decay progresses (an initial loss of N in the early stages of decay, then an immobilisation stage followed by a release phase)
- Mass loss due to decay decreased with increase in diameter
- The results indicate a difficulty in comparing results from the trenched plots with those from the buried decomposition bags

4. Publication

Samuel Olajuyigbe, Brian Tobin, Michael Hawkins, Maarten Nieuwenhuis, 2012. The measurement of woody root decomposition using two methodologies in a Sitka spruce forest ecosystem. *Plant and Soil.*

doi: *10.1007/s11104-012-1222-7*



Conceptual model of CWD decomposition

Solid arrows = transformation

Broken arrows= processes

Dotted arrows = influencing factors

General Conclusions

- Decay rates help improve C flux models used for C reporting
- CWD has great potential for C storage, especially, belowground
- The impact of CWD biomass harvesting on the C, N and ecological processes of managed forest
- The contributions of CWD to net ecosystem C exchange should be accounted for in forest C budgets

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Thank you for listening