Fuelwood forestry and biodiversity conservation

A focus on the European case study

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International Symposium
On dynamics and ecological services of deadwood in forest ecosystems

Rouyn-Noranda, May, 16, 2011

Contents

CONTEXT

- Concerns over climate change mitigation activities, peak oil and energy security
- Use of renewable and alternative energies and forest-based bioenergy

International Symposium
On dynamics and ecological services of deadwood in forest ecosystems

WOOD-DERIVED FUELS

3 sources of forest biomass material:

<u>Wood waste</u>

packaging materials, construction and demolition waste, tree trimmings, pallets

<u>Wood energy crops</u>

stands of fast-growing trees

<u>Forest residues</u>

tree tops, smaller limbs, small thinned trees, stumps

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I

Fuelwood and forest environment

Potential changes in forest practices induced by fuelwood development

- extension of traditional fuelwood collection
- changes in harvesting practices
  - whole-tree harvesting
  - post-harvest recovery of residues
    - small trees
    - slash
    - logging residues
    - logs of low quality
    - stumps


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Other changes related to forestry intensification


Walter Murch


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- ↑ density of cutting areas
  - extensive thinning and clearing
  - felling of previously unmanaged forests (protected, abandoned…)
- road construction > ↑ forest access
- ↓ forestry cycle duration
- conversion of native forests into short-rotation coppices

Regional contrasts in pressing issues

<table>
<tr><th>Forestry</th><th>Boreal</th><th>Temperate</th></tr>
<tr><td>Characteristics</td><td>▪ Industrial forest companies
▪ Large scale
▪ Environmental regulation</td><td>▪ Fine-grain fragmented ownership and management
▪ High proportion of poorly-managed forests
▪ Fuzzy environmental rules</td></tr>
<tr><td rowspan="2">Main fuelwood-driven changes</td><td>▪ ↑ post-harvest recovery of residues (FWD and stumps)</td><td>▪ ↓ % unmanaged forests = ↑ density of fellings
▪ ↑ forest roads and access
▪ ↓ forestry cycle duration and ↑ old tree harvesting</td></tr>
<tr><td colspan="2">▪ ↑ whole-tree harvests
▪ ↑ traditional fuelwood collection?
▪ ↑ conversion of forests into short-rotation coppices?</td></tr>
</table>

Key constraints to fuelwood development

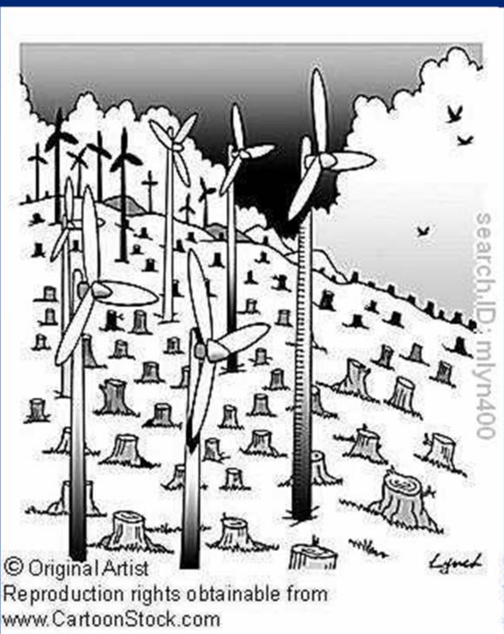
ENVIRONMENT

- Accessibility
- Environmentally sensitive areas

FORESTRY

- Environmental regulations
- Federal funding for forestry programs
- Labor availability / skilled forestry workers
- Availability of specialized equipment
- Transportation costs
- …Bioenergy values and market stability

Potential environmental effects of bioenergy-related forest practices



SOIL

- ↓ organic matter and nutrients
- ↑ risk of soil acidity
- ↓ protective mats of harvesting residues
- ↑ soil compaction and rutting by machinery

GHG BALANCE

- ↓ GHG
- ↓ soil carbon storage

WATER

- ↓ infiltration
- ↑ movement
- ↑ water turbidity and [nutrient]

FIRE RISK

PEST RISK

Potential environmental effects of bioenergy-related forest practices

- Changing conditions for biodiversity
  - Habitat loss and fragmentation
    - Changes in deadwood volume and profile
    - ↓ density in old stands and veteran trees
  - Changes in soil conditions
  - ↑ internal edges and ↓forest interior habitats
  - Enhanced disturbance to fauna
    - ↑ access roads: barrier effects, casualties

Reduction of deadwood availability

- General forest management
  - In Swedish managed forests:
    - CWD ↓ 2-10% of the amounts in natural forests
    - Spruce FWD has increased by 75% since 1920
      - Caruso (2008)
- How many snags, down CWD and FWD actually remain after intensified woodfuel harvests?

DW volume at the plot scale

"You have a killer resume, Phil, and terrific recommendations. Unfortunately, we have all the dead wood we need at present!"

(-)

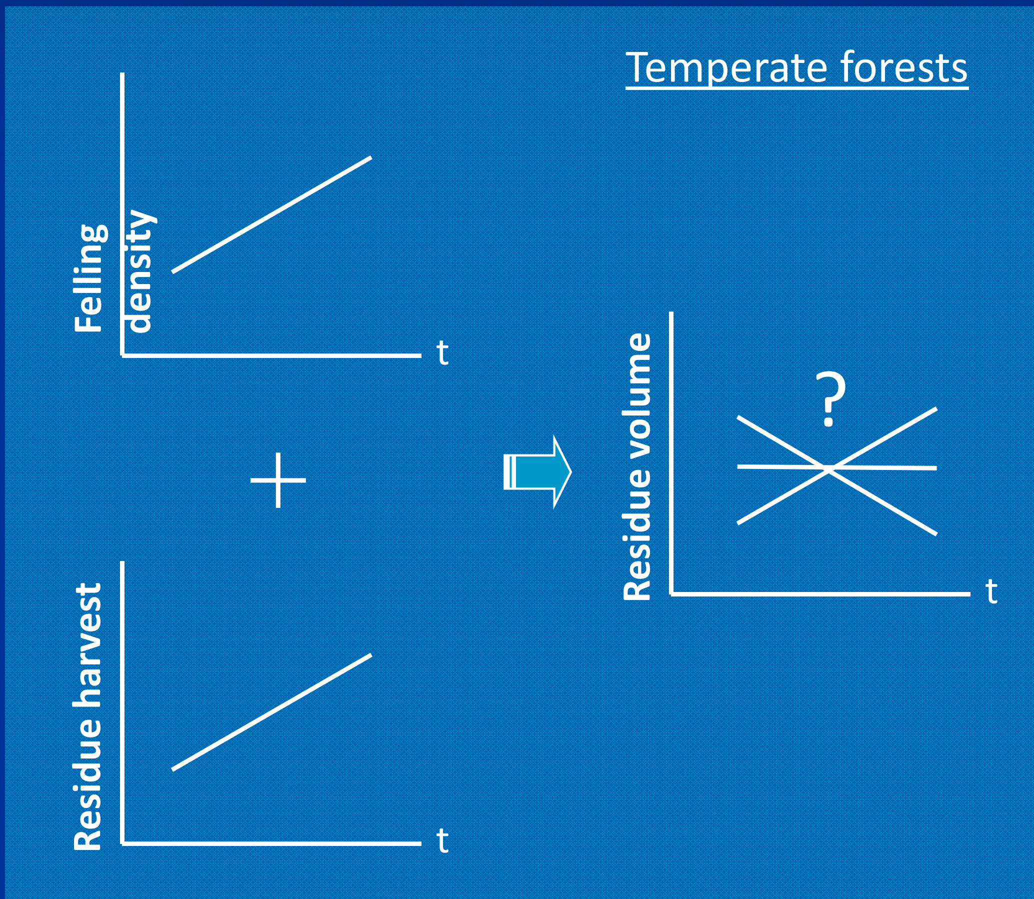
- whole-tree harvesting
- post-harvest recovery of residues (FWD, stumps…)
- ↑ destruction of deadwood pieces by machinery
- ↓ natural input of deadwood due to the shortening of forestry cycle duration and harvesting of older trees

DW volume at the plot scale: empirical studies

- Quantitative data are scarce in temperate forests
  - Arnosti et al., 2008, USA
- In boreal forests

Reference	Removal during residue harvest
Ericsson, 2003 Rudolphi and Gustafsson, 2005	75% of existing deadwood and residues from final harvesting
Rudolphi and Gustafsson, 2005	40% of the decomposing logs present before
Allmér, 2005	6% of deadwood and 45% of FWD

DW volume at the landscape scale: modelling studies



Scenarii with an intensification of log biomass removal

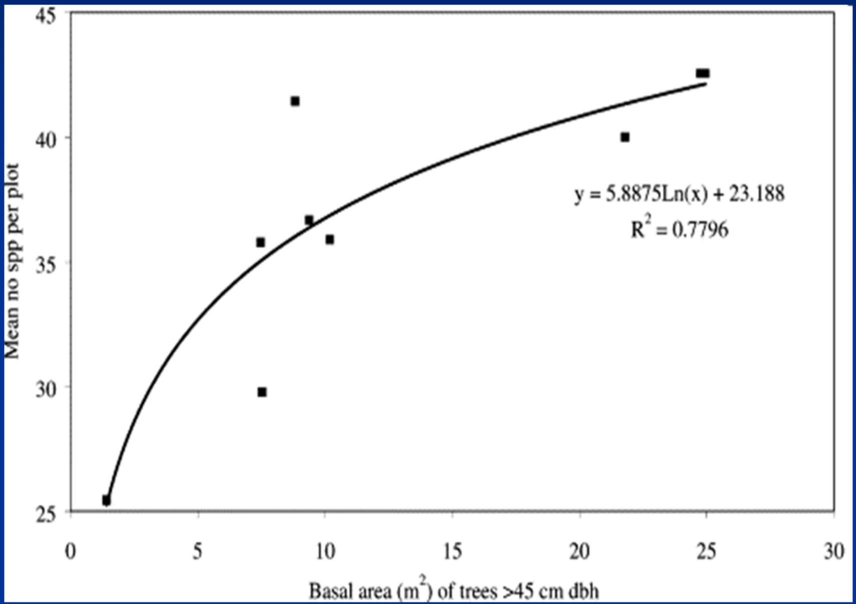
- In nordic landscapes
  - An overall reduction?
    - Ranius et al. (this workshop)
- In temperate landscapes
  - Compensation processes?
    - (-) ↑ recovery of residues
    - (+) ↑ density of cutting areas (some with DW retention)
- At the European level
  - 2005<>2030: ↓ 5.5% DW volume
    - Verkerk et al. (2011)

II - Fuelwood and saproxylic biodiversity

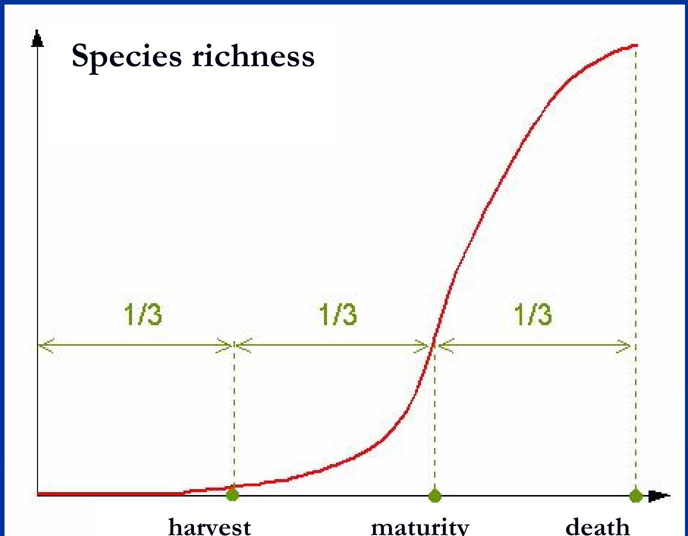
1. Response to decreased density of old trees
2. Response to decreased DW volume
3. Response to logging residues harvesting
4. Response to stump harvesting

Response to decreased density of old trees

Response to decreased density of old stands and veteran trees



Grove, 2002



Branquart, 2005

- Positive relationship between species richness of saproxylic beetles and
  - trunk diameter
    - Ranius & Jansson, 2000
  - basal area of large trees
    - Grove, 2002
  - ?tree age
    - Branquart, 2005
- Risks in temperate forests:
  - Decrease in forestry cycle rotations
  - Harvests in natural-like forests

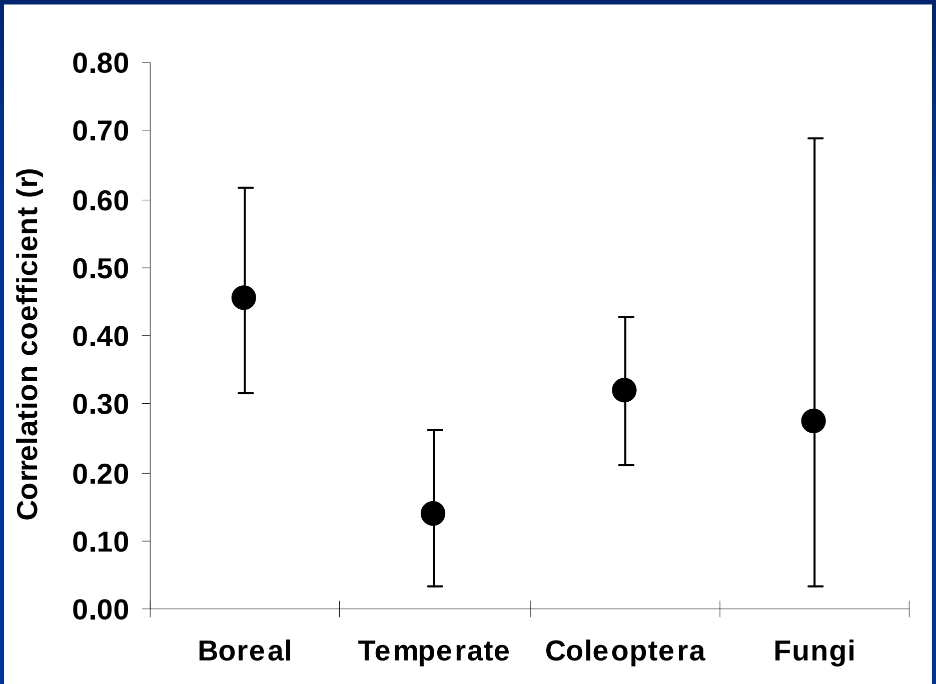
A peculiar case study: pollard trees

- In agricultural landscapes structured by hedgerows and orchards

- Pollard trees
  - fuelwood
  - alternative habitats for saproxylic beetles inhabiting mature trees
    Ex. Osmoderma eremita

Response to decreased DW volume

Response to decreased DW volume



Literature meta-analysis, Lassauce et al. (2011) Ecol.Indicators

- Plot scale
  - Unclear relationship btw local DW volume and biodiversity
    - Better correlations in boreal than in temperate forests
      - Meta-analysis: Lassauce et al. (this workshop)
- Landscape scale
  - A few results on broad scale positive effects of DW
    - Franc et al., 2007, Gibb et al., 2006, Okland et al., 1996…
- In boreal forests, many saproxylic species
  - adapted to large-scale disturbances and sun-exposed substrates
  - Important populations in clearcut residues on a landscape level

Response to logging residue harvesting

What are harvesting residues?

- Small fallen trees from precommercial thinning operations
- Tree tops from logging operations
- Lying branches
  - Fine Woody Debris (<10cm)

What life in the FWD?

Lichens, bryophytes

Kruys & Jonsson, 1999 ; Caruso & Rudolphi, 2009 ; Caruso & Thor, 2007

Saproxylic beetles

Nitterus et al., 2004, Manak, 2007, Gedminas et al., 2007, Jonsell et al., 2007, Jonsell, 2008, Ferro et al., 2009, Brin et al., 2011, Lassauce & Bouget (subm.)

Fungi

Kruys & Jonsson, 1999, Norden et al., 2004, Heilmann-Clausen & Christensen, 2004, Kuffer & Senn-Irlet, 2005

Saproxylic Diptera

Gedminas et al., 2007

Ecological drivers of biodiversity in logging residues (FWD)

- Deadwood quality
  - Diameter
  - Tree species
  - Decay stage
- Environment
  - Sun exposure
  - Soil moisture
  - Local species pool

What's different between FWD and larger CWD?

- Differences in species composition
  - Beetles
    - Jonsell et al., 2007, Brin et al., 2011, Lassauce & Bouget, subm.
  - Lichens
    - Caruso & Thor, 2007 ; Caruso et al., 2008

- FWD specialists
  - twig assemblages are not just nested subsets of bole assemblages

Are there twig beetle specialists?

Anobiidae	Ernobius angusticollis
	Ernobius nigrinus
	Ernobius longicornis
Cerambycidae	Pogonocherus decoratus
	Obrium brunneum
	Pogonochaerus caroli
Curculionidae	Magdalis phlegmatica
	Magdalis frontalis
	Magdalis linearis
	Magdalis nitida
	Magdalis duplicata
Oedemeridae	Chrysanthia geniculata
Scolytinae	Carphoborus minimus
	Crypturgus cribrellus
	Hylastes angustatus
	Hylastes opacus
	Pityophthorus pubescens
	Pityophthorus glabratus

Ex. Beetle sp. in French conifer and deciduous FWD

Anobiidae	Xyletinus fibyensis
	Xyletinus laticollis
Anthribidae	Phaeochrotes pudens
Bostrichidae	Sinoxylon muricatum
Buprestidae	Agrilus betuleti
	Agrilus convexicollis
Cerambycidae	Grammoptera ustulata
	Anaesthetis testacea
	Exocentrus adspersus
	Leiopus punctulatus
	Pogonocherus hispidulus
	Pogonocherus hispidus
	Grammoptera abdominalis
	Nathrius brevipennis
	Exocentrus lusitanus
	Stenostola dubia
	Glaphyra umbellatarum
Curculionidae	Magdalis barbicornis
	Magdalis ruficornis
	Magdalis flavicornis
	Magdalis exarata
Scolytinae	Phloeotribus rhododactylus
	Hylastes attenuatus
	Ernoporicus caucasicus

Methods to investigate twig beetle specialists:

- Dissection
- Emergence
- Beating and collecting

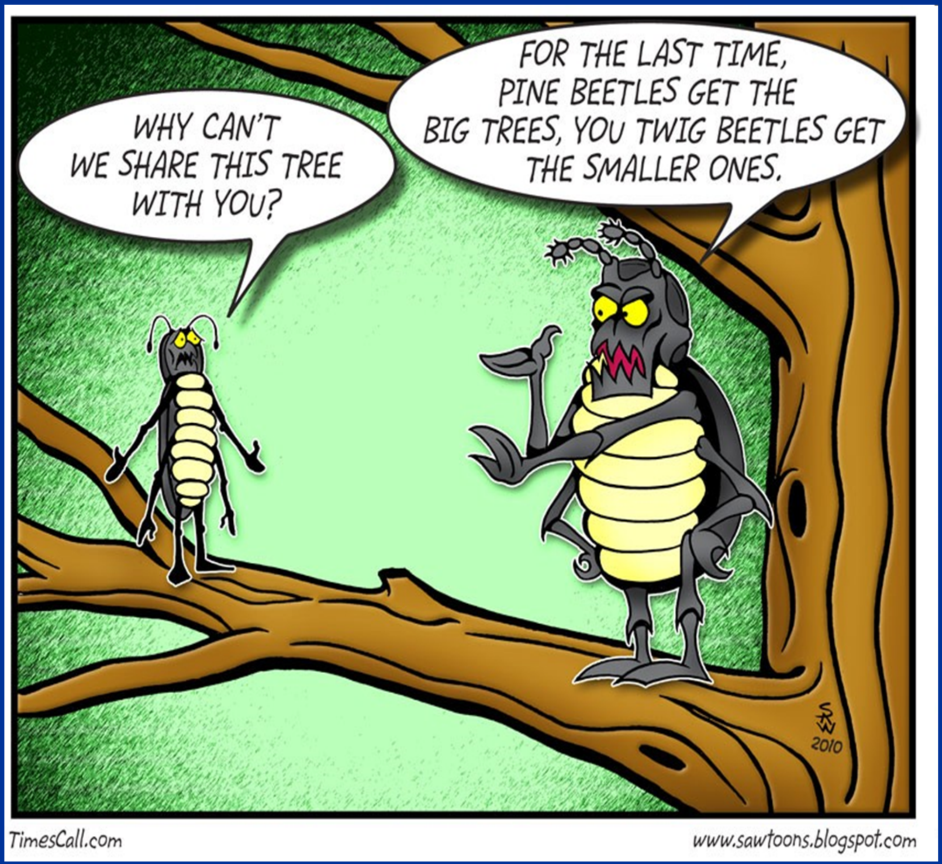
(Jonsell and Hansson, 2007 ; Grove, 2009)

What's different between FWD and larger CWD?

- Differences in species density
  - but…
    - standardization mode: area, volume, no of elements?
      - Schiegg, 2001
    - diameter range
- Rare species in FWD
  - Lichens
    - Caruso & Thor, 2007
      Caruso et al., 2008
  - Beetles
    - Jonsell et al., 2007
    - Brin et al., 2011

Ecological processes underlying the difference between FWD and CWD

(Brin et al., 2011)



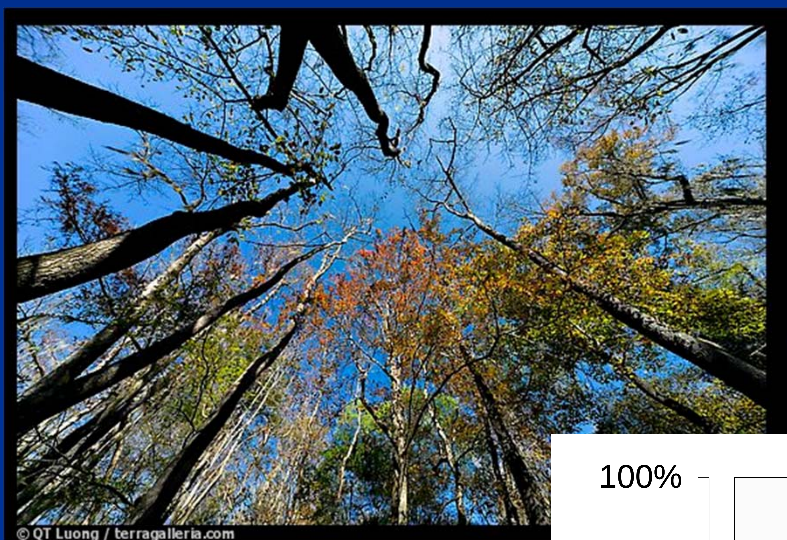
1. substrate heterogeneity
   number of feeding niches
2. microclimatic stability
3. life span
4. quantity of available resources per DW piece
5. bark thickness
6. decay pathways

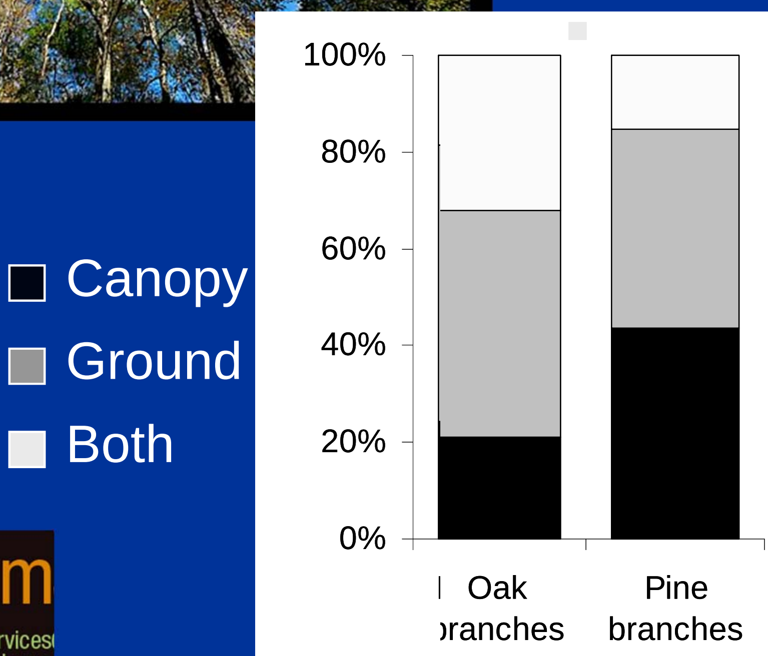
Importance of FWD tree species

- More species and red-listed species in deciduous than in coniferous residues
  - Fungi
    - Norden et al., 2004
  - Beetles
    - Jonsell et al., 2007
    - Lassauce and Bouget, subm.

Comparison between lying and hanging dead branches

Suspended dead branches = potential alternative substrates for all the FWD species?





- Microclimate vertical stratification (moisture…)
- A significant inter-strata dissimilarity
    - Bouget et al. (2011) Ulyshen and Hanula (2007) Foit (2010) Hammond et al. (2004) Manak (2007) Schroeder et al. (2009)
- Stratum-specialist taxa
    - Exclusive canopy species = 20 - 40%
        - (Bouget et al., 2011)
- Arboreal saproxylic beetle communities
    - = not just nested subsets of ground assemblages

What about the effects of delayed extraction?

- Delayed extraction for nutrient retention
  - in situ "drying" to limit extraction of nutrients from needles/leaves
    - (Cacot et al., 2006)
- Assemblages and decay dynamics
  - Especially for deciduous tree species
    - Jonsell et al., 2007 ; Lassauce & Bouget (subm.) – saproxylic beetles
    - Species richness in residues: decayed > fresh
    - Decay class > important factor for sp. composition
- Delayed extraction might be <u>counterproductive</u>!

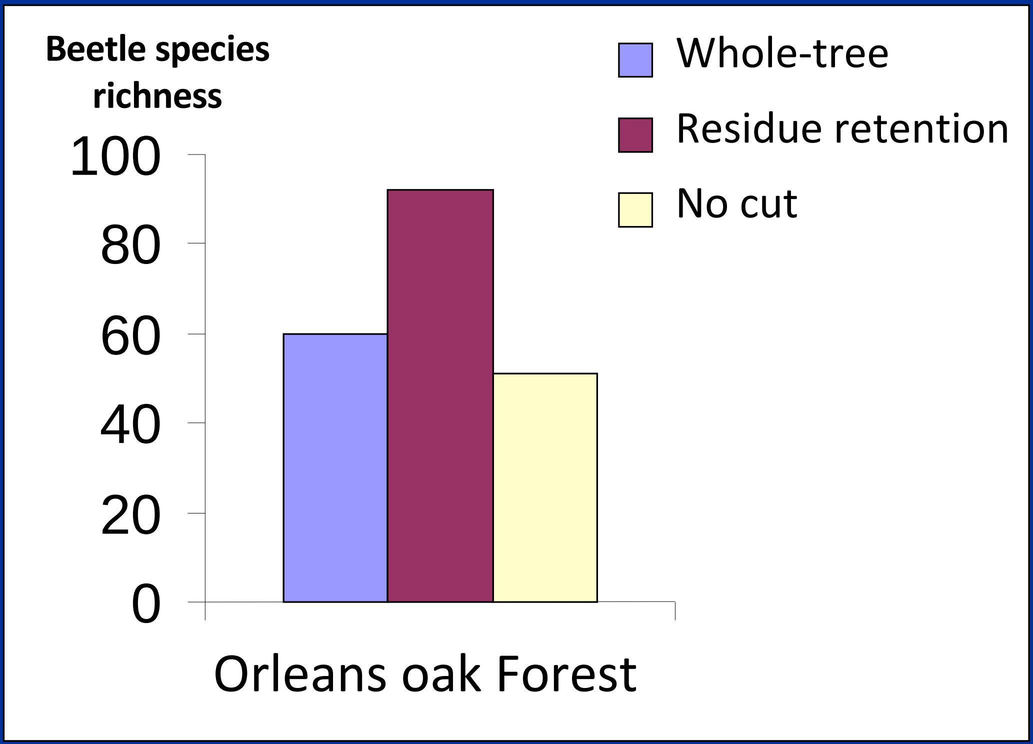
Ecological trapping by log piles

Woodpiles may act as ecological traps!

- Harvested wood stored in piles and allowed to dry for one summer
- Aggregations of fresh dead wood attract laying beetle females
- Mitigate the negative effects of piles:
  - remove the piles before the insects colonize them
  - retain the top layer of the piles (preferred by most beetles)

(Hedin et al., 2008)

Impact of slash removal on saproxylic biodiversity

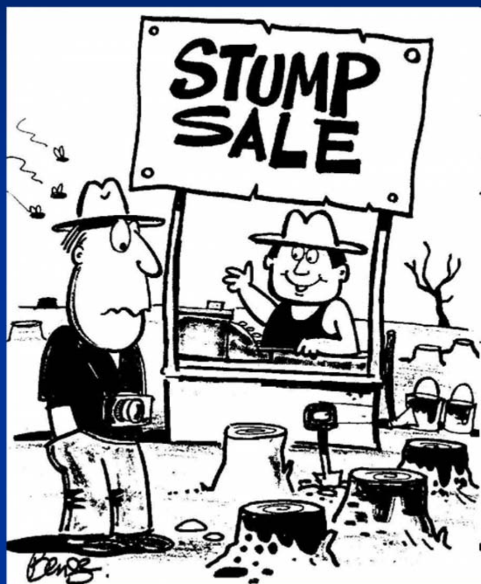


Comparison of saproxylic beetle biodiversity in sites with (FW) or without (nFW) fuelwood harvesting

- Grove, 2009
  - ↓ abundance and ≠ assemblages in FW vs nFW
- Bouget (unpublished)
  - ↓ species (esp. secondary xylophagous) in FW vs nFW

Response to stump harvesting

Stump harvesting in Europe



- In Sweden and Finland
  - Stump harvesting in the 1970s and 80s for use as pulp wood and abandoned
  - expansion since 2002 in Finland, and since 2009 in Sweden
- in GB?
- In South-western France?

Stumps as « trivial dead wood »?

Stump = a common, widespread deadwood type

- Overlooked in ecological studies
  - Pioneer studies on pine stumps
    - Wallace, 1953 (GB), Elton et al., 1964 (NL)
- Not considered in deadwood estimates

Stump volume in deadwood stocks

Stump volume			
2 %CWD	Managed/unmanaged mature oak forests	Temperate France	Bouget, unpublished
11 %CWD	Managed pine plantations	Temperate France	Brin et al., 2009
28 %CWD	managed forests	Boreal Sweden	Jonsell, unpublished
Stumps=3x [logs/high stumps]	clearcuts	Boreal Sweden	Hjältèn et al., 2010
80 %CWD	clearcuts	Boreal Sweden	Caruso et al., 2008

Importance of low stumps for biodiversity

Are stumps as species-rich as downed logs and snags?

Beetle sp richness

Zone	Tree species	Reference	logs		stumps		snags
Boreal	spruce	*Hjältén et al., 2010*		=		=	
Boreal	birch, aspen, pine, spruce	*Jonsell et al., subm*		=			
Temperate	oak	*Bouget, unpubl*		<		=	

Importance of low stumps for biodiversity

Are beetle assemblages in stumps different from those in logs and snags?

Beetle sp composition

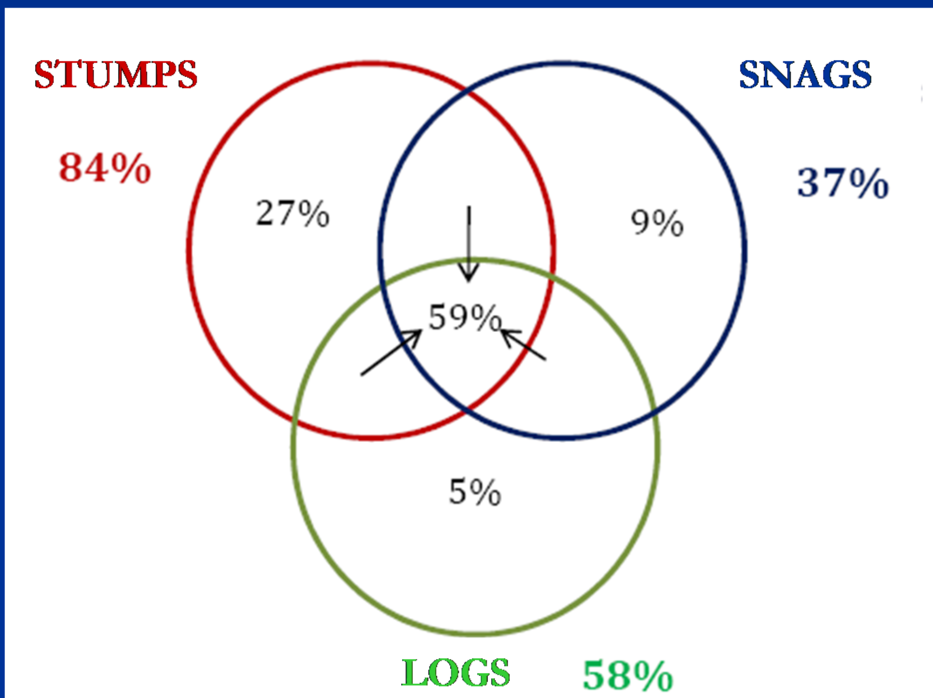
			logs		stumps		snags
Boreal	spruce	*Hjältén et al., 2010*		≠		≠	
Boreal	birch, aspen, pine, spruce	*Jonsell et al., subm*		≠			
Temperate	oak	*Bouget, unpubl*		=		≠	

Importance of low stumps for biodiversity

Beetle dissimilarity btw stumps and logs:

- Tree species?
  - ≠ stronger for coniferous (pine, spruce) than deciduous (aspen, birch) trees
    - Jonsell et al., subm.
- Deadwood age?
  - ≠ stronger for fresh than decayed wood
    - Jonsell et al., subm.
- Species common in spruce low stumps also reported from other substrate types
    - Hjältén et al., 2010

Importance of low stumps for biodiversity



Saproxylic beetle species in pine micro-habitats
in SW France (Brin, unpubl.)

- Man-made stumps as key micro-habitats
  - more homogeneous than logs
  - but LT continuity and decay diversity
  - = alternative micro-habitats
    - beetles
      - Pine plantations in SW France (Brin, unpubl.)
    - Bryophytes
      - French oak forests (Gautrot, unpubl.)
- What original habitat for stump-associated species?
  - low stumps ≠ snag basis
    - beetles: Abrahamsson & Lindbladh, 2006
    - parasitoids: Hedgren, 2007

Importance of low stumps for biodiversity

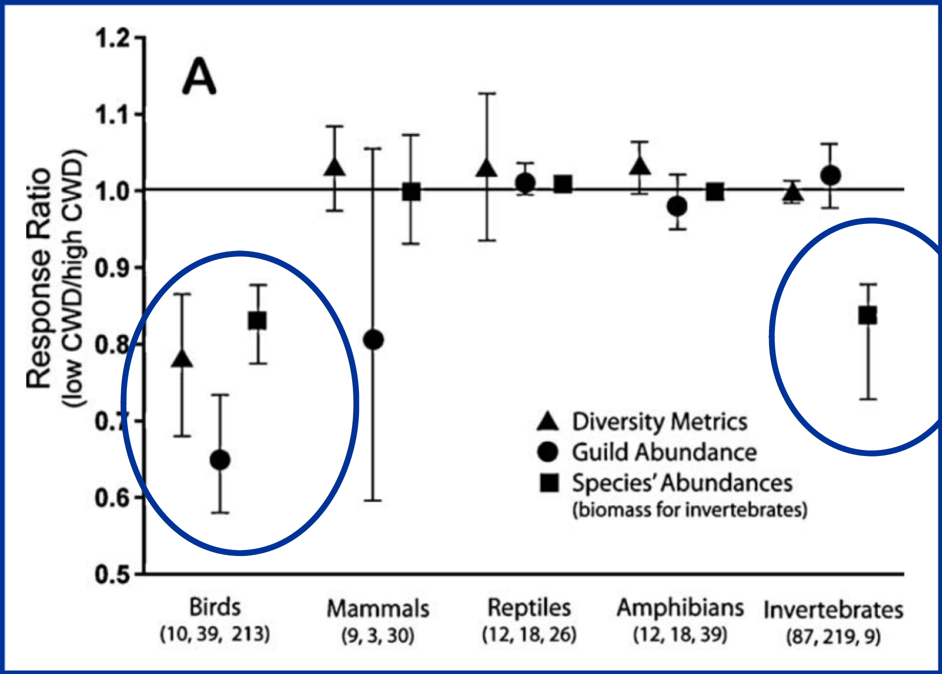
Do rare species occur in stumps?

	Rare species in stumps	
Mosses	–	Caruso & Rudolphi, 2009
Lichens	+ / -	Caruso & Rudolphi, 2009
Saproxylic fungi	–	Hottola, 2009
Saproxylic beetles	+	Jonsell et al., subm. Bouget, unpubl.

III

Fuelwood and non-saproxylic biodiversity

Residue removal and wildlife



Riffell et al., 2011

- Meta-analysis of impact of FWD harvest on biodiversity in North America
- FWD is not only a direct substrate but an important habitat feature for many types of wildlife

Residue removal and non-saproxylic biodiversity

Piles of slash and residues used by Vertebrates as:

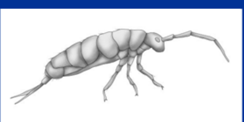
- means of traversing their home range
- protective cover
- nesting sites
- feeding areas

- Wildlife response to changes in FWD (Riffell et al., 2011)
  - mice, voles and shrews
    Ecke et al., 2002 ; Manning and Edge, 2008
  - marten
    Bunnell et al., 2002
  - small birds
    Hanowski et al., 2003
  - amphibians

Residue removal and soil arthropods

Piles of slash and residues > changes in substrate and micro-climate for soil arthropods

Effect of slash removal on soil arthropods



Group	Variable	Time scale	Effect of slash removal	Reference
Mites and springtails	Density Composition	Short-term	(-) ns	Bird & Chatarpaul, 1986
Mites	Density/diversity	Short-term	(-)	Battigelli et al., 2004
Spiders	Density	Long-term	(-)	Bengtsson *et al.*, 1997
Enchytreids, Nematodes, springtails			ns	
Ground beetles		Short-term	(-)	Nitterus *et al.*, 2007
Spiders			ns	
			(-)	Castro and Wise, 2009
	Composition		(+)	
Soil-dwelling beetles	Sp. Richness		(-)	Gunnarson *et al.*, 2004
Nematodes	Density	Mid-term	(-)	Sohlenius, 1996
	Composition		(+)	

Residue removal and soil acidification

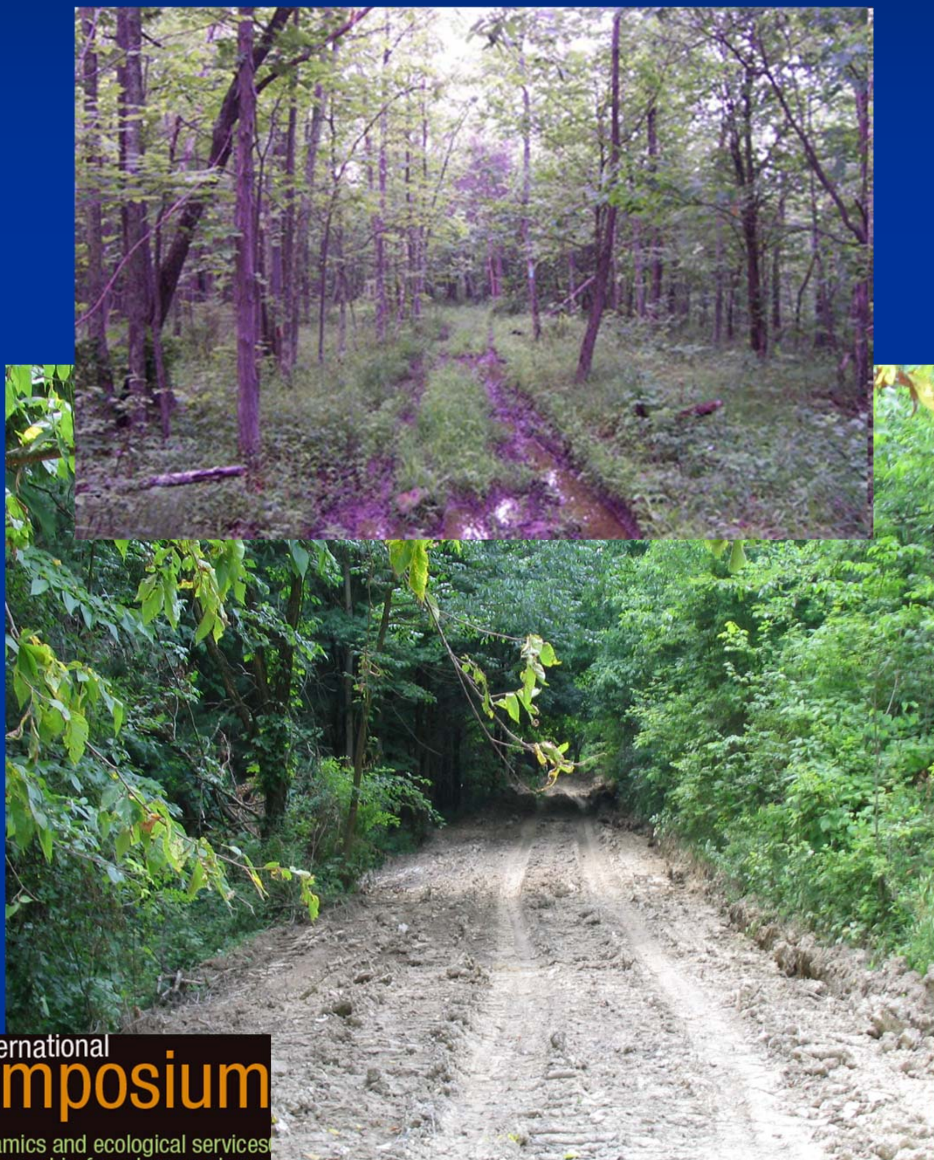
- Fauna
  - Soil decomposer and microbial activity
    - Baath et al. (1980)
  - Amphibians as bioindicators of acidification
    - (Wyman and Jancola, 1992)
- Flora

Residue removal and flora

Piles of slash and residues > physical and geochemical changes for vascular flora

- Short-term mulching effect
  - ↓ herbaceous cover
    - Olsson & Staaf, 1995
    - Brakenhielm & Liu, 1998
    - Deconchat & Balent, 2001
    - Aström et al., 2005
- Physical protection from browsing
    - Bergquist, 1998

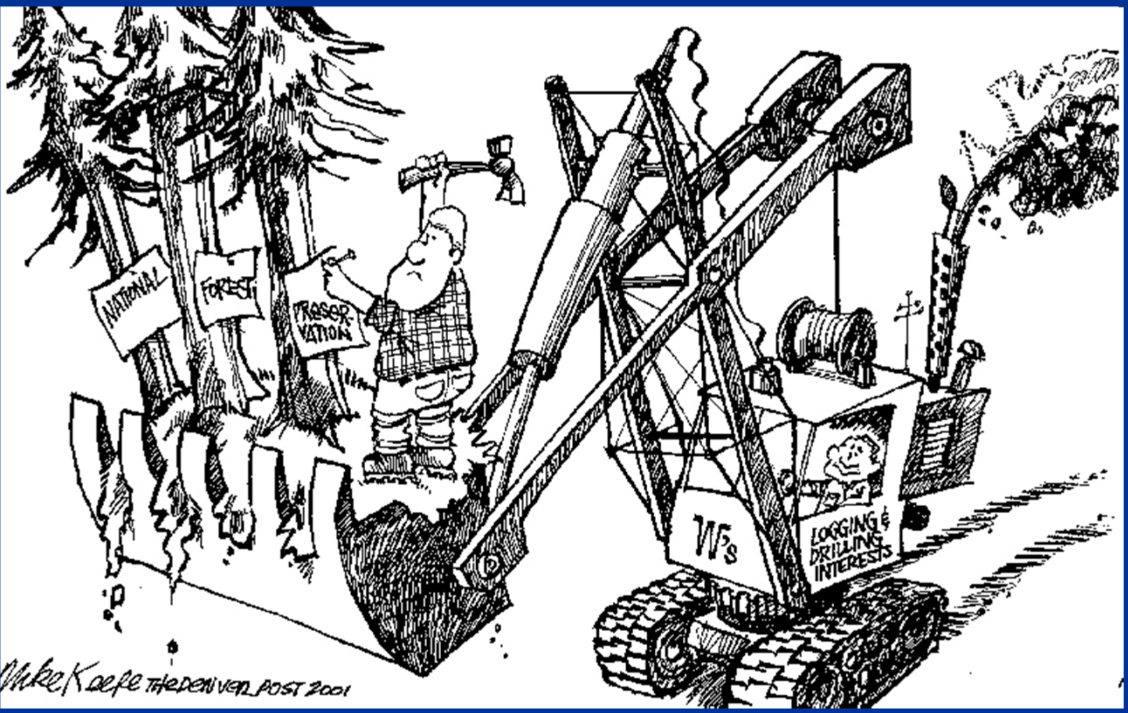
Bioenergy-related practices and soil compaction



- Soil compaction
  - Flora
    - Species adapted to hypoxic conditions
      - Godefroid and Koedam, 2004
  - Soil fauna
    - Mite density and diversity
      - Battigelli et al., 2004
    - Biological activity
      - Radford et al., 2001
- Logging trails with retained woody material to reduce forest machine ground pressure

Conclusion

Cautionary statements to mitigate ecological damage on biodiversity

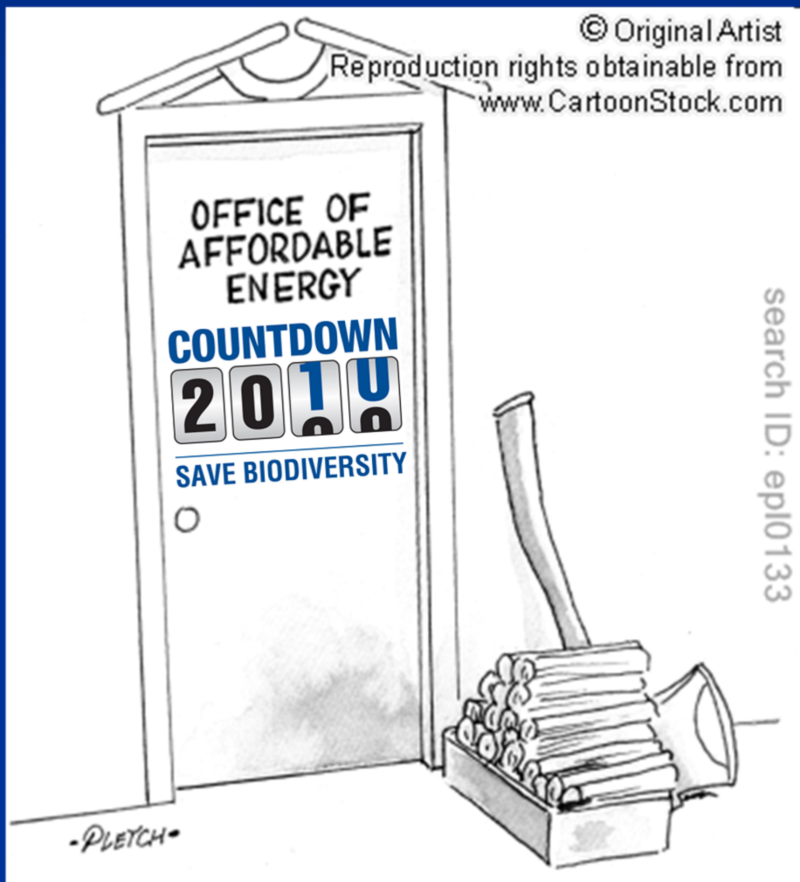


- Incorporate regional wildlife management guidelines into biomass production systems
  - development of environmentally friendly collecting practices
  - complete Life Cycle Analysis (LCA) of fuelwoods
    - incl. fossil fuels used in production and transport

Recommendations to minimize negative impacts on biodiversity

- Harvest recommendations
  - account for the context (region/forest/biome)
  - difficult to set an appropriate level of extraction/retention
    - Area specialization strategy
      - site classification based on conservation values
      - restrict/concentrate residue harvesting in stands with high/low values
  - safeguarding principles
    - threshold frequency of residue harvesting per rotation

Research requirements



Further research:

- Manipulative experiments
- Large-scale experiments
- Landscape analyses
  - landscape-level effects
- Long-term studies
  - delayed impacts of fuelwood harvesting (decay dynamics/extinction debt)
- Multi-taxonomical approaches
- Adaptive management

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Thanks for your attention!

Thanks for initial debates to Frédéric Gosselin, Marion Gosselin and Guy Landmann

Next workshop…