Integrating Biodiversity Metrics in Life-Cycle Assessment of Intensive Biomass Production in North American Forests:

Challenges and Considerations

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Life Cycle Assessment

Life Cycle Assessment: "compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle" (ISO 2006a, b)

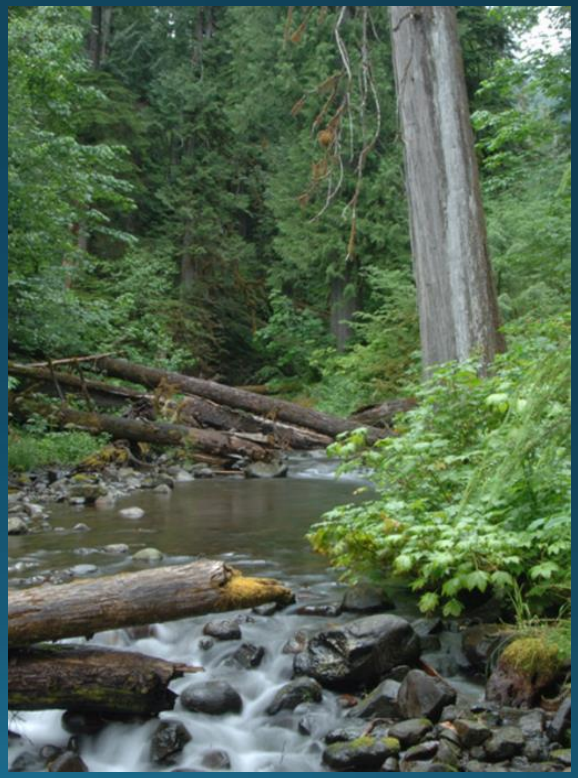
Life Cycle Impact Assessment (LCIA) is one of the phases in the LCA methodology

LCIA is used to assess the relative environmental significance of Life Cycle Inventory results (e.g. resources extracted, releases to air, water, etc.)

LCIA requires quantification of meaningful indicators

Areas of Protection

- Human health
- Natural environment
- Natural resources - (sustainability considerations)
- Man-made structures and ecosystems



Udo de Haes et al. (1999) – SEATAC Europe

Impact Categories for LCIA

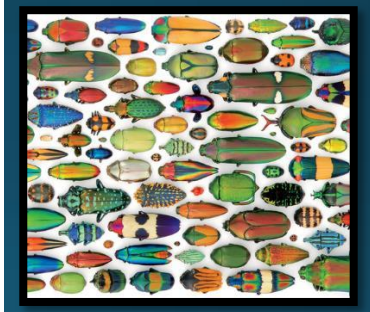
Nine commonly applied Impact Categories:

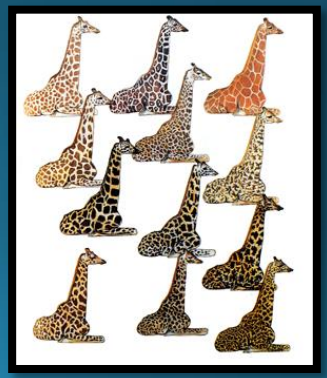
1. Climate change
2. Stratospheric ozone depletion
3. Photo-oxidant formation
4. Acidification
5. Nitrification
6. Human toxicity
7. Ecotoxicity
8. Depletion of abiotic resources (fossil fuels, minerals, etc.)
9. Unsustainable use of biotic resources (wood, fish, etc.)

Others? Land Use?

Levels of Biodiversity

- Ecological diversity (ecosystems and landscapes; abiotic & biotic)





Direct vs. Indirect Biodiversity Indicators

Direct indicators - biological or taxon based

- Indicator species
- Guilds
- Richness
- Presence of functional groups

Indirect indicators - vegetation structure or habitat based

- Often selected in the absence of information on direct indicators
- Usefulness depends on:
  - Whether the relationship is between organisms and their habitat is linear
  - Taxonomic groups being considered, and the correlation of their responses to habitat manipulations

Commonly Used Indicators of Biodiversity Response to Land Use

- Species Richness

  Geyer, (2010)
  Goedkoop and Spriemsma (2001)
  Koellner and Scholz (2008)
  Kollner (2000)
  Lindeijer (2000)
  Schmidt (2008)

- Species-area relationship

  DeSchryver et al. (2010)
  Koellner and Scholz (2008)
  Kollner (2003)
  Schmidt (2008)

- Number of threatened species

  Koellner and Scholz (2008)
  Schmidt (2008)
  Lenzen (2009)

- Fragmentation

  Jordaan et al. (2009)
  Schenk (2001)

Challenges Associated with Intrinsic Complexities of Biodiversity

- Consideration of scale largely absent
- Most data are geographically or taxonomically restricted
- Disproportionate focus on indicators that reflect changes in species richness; ignoring the other levels of biodiversity
- Indicators often miss functional and structural attributes of biodiversity
- Invasive species and overexploitation (drivers of biodiversity) are often overlooked

(Curran et al. 2011)

Challenges Associated with Assessment of Biodiversity Effects in LCA Framework

- Existing LCIA methods developed for Europe often using plant species richness as the primary indicator
- Reaction of plants to land use change may not be indicative of the other 98% of terrestrial species
- May approximate some land use impacts on biodiversity but are not intended to provide site specific guidance (Baan et al. 2012)

Commonly Selected Indicators of Forest Biodiversity

- Direct (taxonomic groups)
  - Birds
  - Cavity nesting birds
  - Small mammals
  - Lepidoptera
  - Carabid beetles
  - Terrestrial salamanders
- Indirect
  - Habitat Connectivity/Fragmentation
  - Stand age - structure
  - Selected or "rare" habitat conditions (e.g. late seral)
  - Climax (undisturbed) plant communities

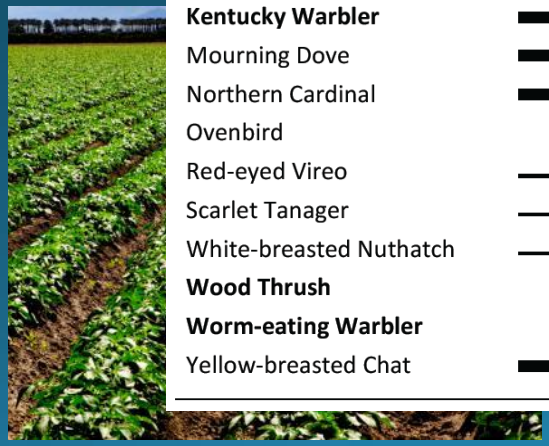






Assumptions for Commonly Used Indicators

- Species richness
- Use of single metrics
- Uni-directional approach
- Reference lands

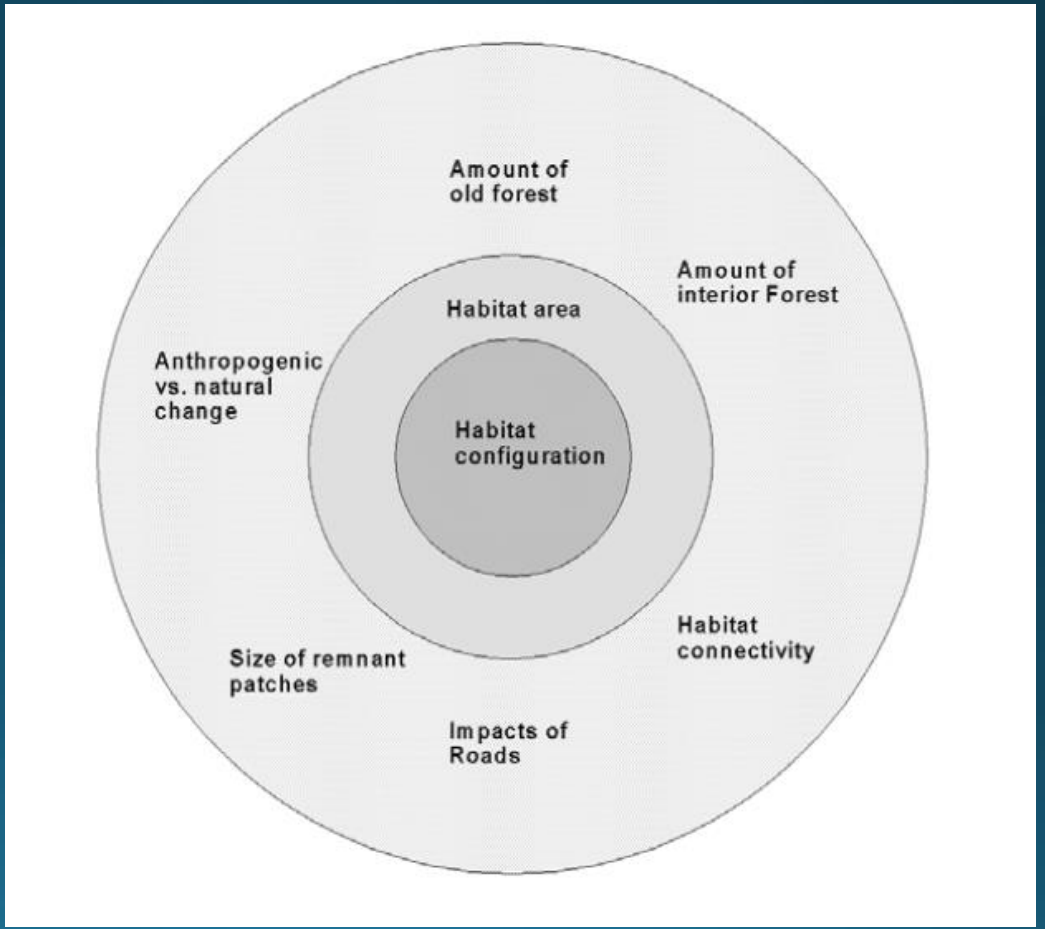


Assumptions for Commonly Used Indicators

- Species richness
- Use of single metrics
- Uni-directional approach
- Reference lands
- Fragmentation

Fragmentation is a Complex Concept

- "Fragmentation" is defined and measured in different ways
- Habitat area may mean more than habitat configuration
- "Habitat" is a species-specific concept
- In managed forests, habitat change is not permanent



Source: Wedeles and Sleep. 2008. NCASI TB 959

Fragmentation is a Complex Concept

- Site productivity can influence effects of disturbance and habitat change on species
- Species mobility will also play a role in response

Implications for Biomass Production Systems

Biodiversity response to forest biomass harvest will be dependent on:

- Biomass production system
- Landscape context
- Geographic scale of harvest
- Frequency and intensity of harvest
- Structure of wildlife communities present
- Species' life history traits

Meta-analyses of Biodiversity Response to Biomass Harvesting

Short-rotation woody crops

Intercropping biomass crops on existing forest lands

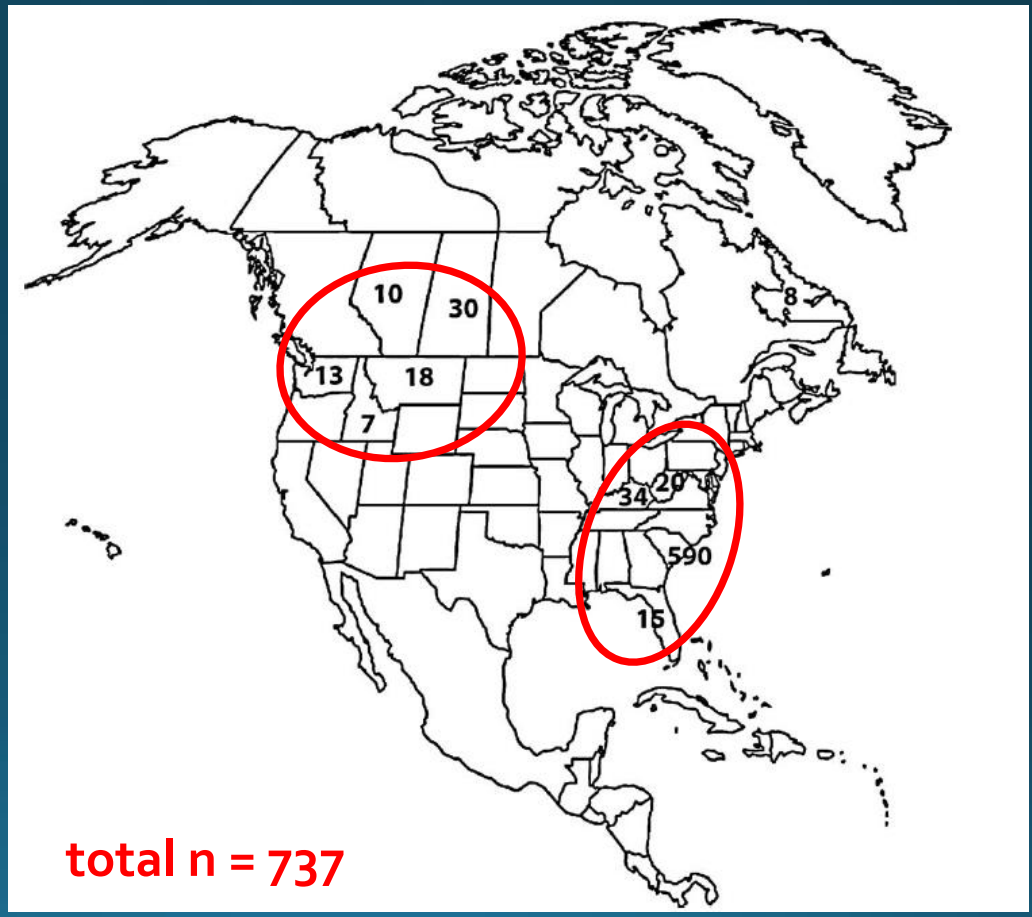
Removal of woody debris

Thinning and fuels treatments

Biodiversity Response to Removal of Harvest Residues

Existing studies

- Have not been conducted in all geographies
- Some taxa are under-represented
- Many have not have involved actual biomass harvests



Source: Riffell et al. 2011 Forest Ecology and Management

Removal of Harvest Residues

Key findings

- Birds are likely to respond negatively
- Response may be driven by lower invertebrate biomass
- Little evidence of strong responses by other taxa

Information Needs

- Better geographic coverage of research
- How much woody debris is left after biomass harvests?
- How do DCWD, FWD, and litter interact?
- How does response vary with landscape context?

Biodiversity Response to Forest Thinning

- Precommercial
- Commercial
- Fuels-treatments

- 33 studies
- 505 individual effect sizes
- 54% of effect sizes for birds
- 17 of 33 studies on mammals

Forest Thinning

Key findings

- Most taxa appear to respond positively
- Species of high conservation priority may warrant special attention
- Biodiversity response likely depends on:
  - Thinning intensity
  - Time since thinning
  - Landscape factors

Information Needs

- Only 3 studies were related to reptiles, all from SE
- Response of reproductive success
- More data about community-level response and response by high-priority species

Intercropping Biomass Crops

Limited research suggests

- Diversity in switchgrass may be
  - Higher than for row crop agriculture
  - Lower than for mixed native warm season grasses
- Weak positive correlations between row spacing and diversity measures
- Positive responses by some early-seral species

Information Needs

- Influences on biodiversity of
  - Stand and landscape characteristics
  - Timing of harvests
  - Other intercropped species
- Can intercropping extend period of early-seral habitat conditions?

Short-rotation Woody Crops

Key findings

- Studies typically compare poplar / cottonwood plantations to mature hardwood forests
- Reported fauna characteristic of these two seral classes
- Few studies or regions

Information Needs

- Better taxonomic and geographic coverage
- Data on responses throughout the entire rotation and across multiple spatial scales
- Comparisons with multiple reference types
- Bird nesting success – not just abundance

Summary

Important to consider indicator quality and assumptions when assessing biodiversity response to land use within LCA

Existing literature indicates:

- Negative effects of forest residue harvest on birds; neutral for other taxonomic groups
- Positive effects of thinning for most taxonomic groups
- Response to SRWC and intercropping is uncertain

Improved information about biodiversity response will inform

- Decisions about ongoing management
- Discussions about the need for and nature of incremental improvements in sustainability guidance

- Riffell, S., J. P. Verschuyl, D. Miller, T. B. Wigley. 2011. Biofuel harvests, coarse woody debris, and biodiversity – A meta-analysis. Forest Ecology and Management 261:878-887.
- Verschuyl, J. P., S. Riffell, D. Miller, T. B. Wigley. 2011. Biodiversity Response to intensive biomass production from forest thinning in North American forests – A meta-analysis. Forest Ecology and Management 261:221–232
- Riffell, S., J. P. Verschuyl, D. Miller, T. B. Wigley. 2011. Biodiversity response to short-rotation woody crops. Global Change Biology Bioenergy 3:313–321.
- Riffell, S., J. P. Verschuyl, D. Miller, T. B. Wigley. 2012. Potential biodiversity response to intercropping herbaceous biomass crops on forest land. Journal of Forestry 110(1): 42-47

Questions?