

*Environ* 2016



UNIVERSITY of LIMERICK  
OILISCOIL LUIMNIGH

# *Life Cycle Assessment (LCA) of Greenhouse Gas Balances in Irish Short Rotation Forestry (SRF)*



Department of  
**Agriculture,  
Food and the Marine**  
An Roinn  
**Talmhaíochta,  
Bia agus Mara**

Mike Clancy, Dr. Ken Byrne - March, 2016.

# ShortFor: Project overview

- **ShortFor?**

- Project funded by Dept. of Agriculture Forestry and the Marine (DAFM).
- Aim: Assess the environmental and economic impacts of Short Rotation Forestry (SRF) biomass for renewable bioenergy.

- **SRF?**

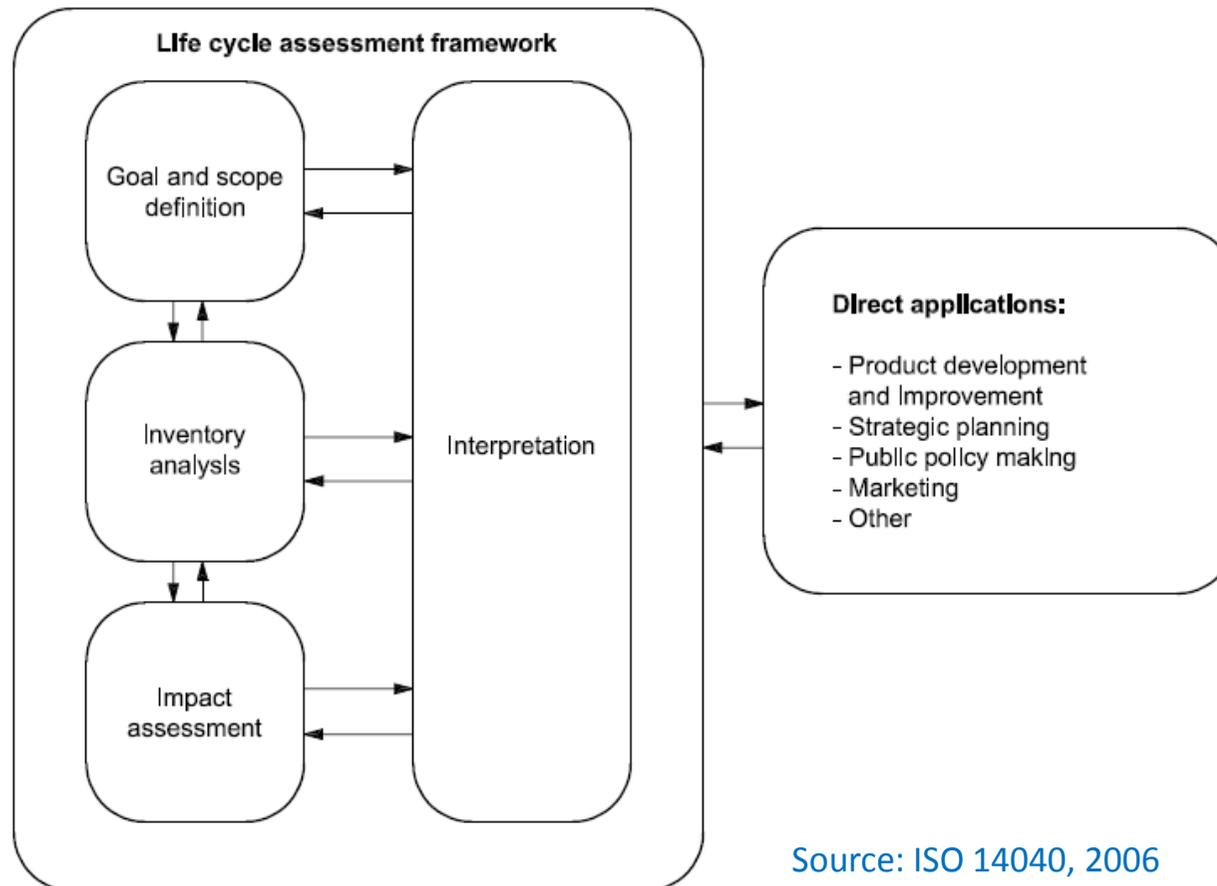
- In this project SRF is confined to single stem species suitable to Irish climate and soil conditions.
- Plantations managed over rotations of 10-15 years.
- Minimum planting density of 2,500 stems ha<sup>-1</sup>.

- **Potential Irish SRF genera?**

- Eucalyptus, Italian Alder, Hybrid aspen & Poplar clones.
- As specified in the DAFM 2014-2020 “Forestry for Fibre” grant and premium scheme.

# LCA framework and applications

- LCA is a method of comparing products and services using the framework outlined below, which can identify environmental impacts attributable to resource consumption, emissions and wastes (Pennington et al, 2004).
- The LCA is usually conducted via specialised software tools and databases, e.g. openLCA v1.42 and ecoinvent v3.1, respectively.



Source: ISO 14040, 2006

# ShortFor: LCA definition

- **Goal:**
  - To assess the greenhouse gas (GHG) balance of Irish SRF, in terms of reaching the goal of 16% renewable energy by 2020.
  - Provide environmental data to assist policy makers in energy, land-use, and forestry planning, and to determine appropriate levels of incentives for SRF bioenergy.
- **Scope:**
  - SRF: Eucalyptus and Alder, over two 15 year rotations
  - SRF bioenergy: Cradle-to-grave (nursery to ash disposal)
  - The “functional unit”, which is a quantitative measure of the functions that the product or service provide, is 1 GJ of energy.

# LCI, LCIA, Interpretation

## 1. Life Cycle Inventory (LCI):

- A compilation of the inputs (resources & energy) and outputs (e.g, GHG emissions) from the product or service over its life-cycle, each defined in relation to the functional unit.

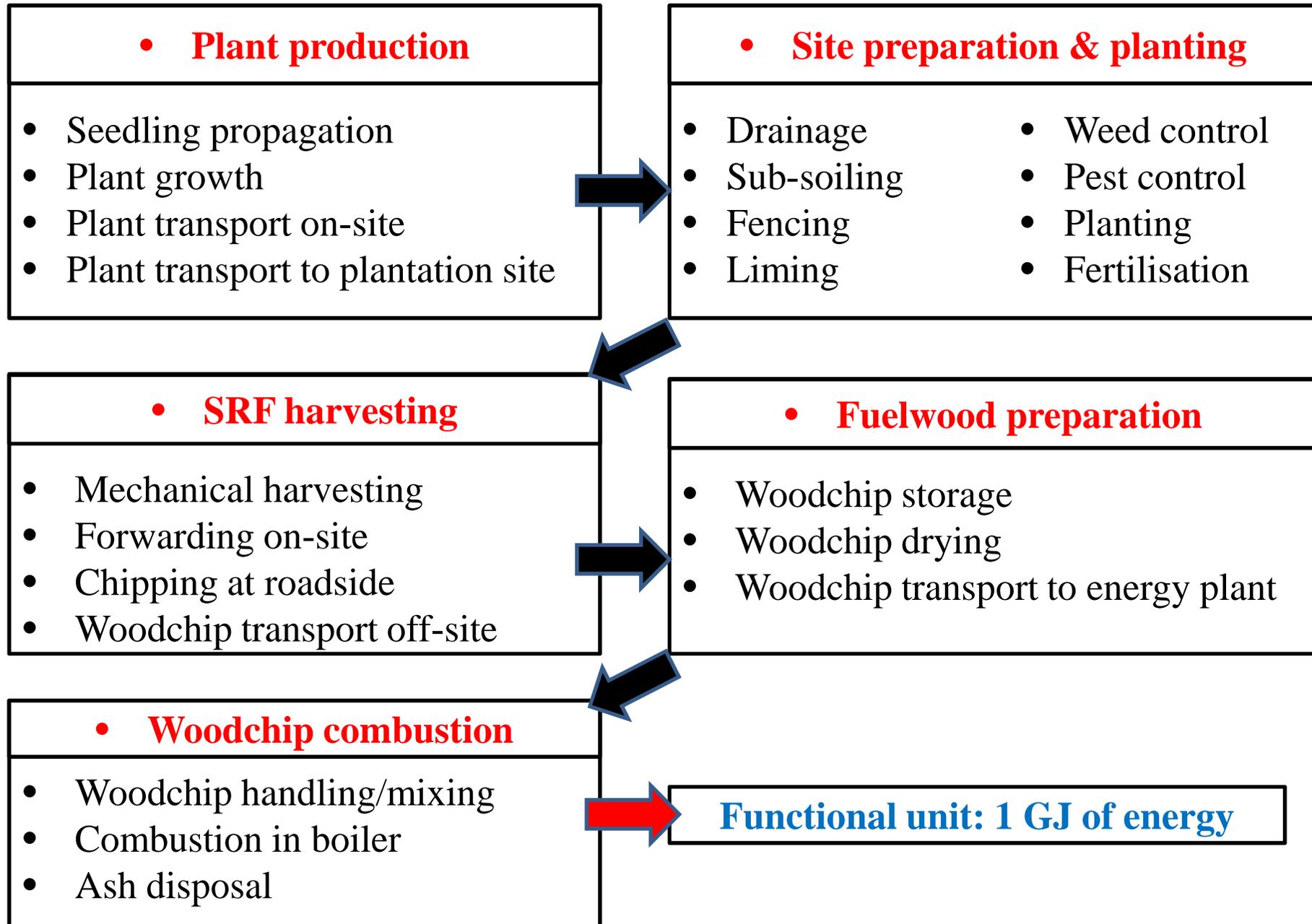
## 2. Life Cycle Impact Assessment (LCIA):

- The LCIA is aimed at evaluating the magnitude and significance of the potential environmental impacts of the studied system using specified indicators (e.g. global warming potential (GWP), eutrophication, acidification).

## 3. Interpretation:

- Results from the previous phases are evaluated in relation to the goal and scope in order to reach conclusions and recommendations.

# SRF LCA system boundary & process map



# Harvesting operations: stems, whole-tree, and stumps





18 yr. old Eucalyptus (*E. nitens*) beside 19 yr. old Sitka spruce,  
Cappoquin, Co Waterford  
(Thompson et al, 2012)



# Comparison of tree biomass over 10-20 yr. rotations

Species	AD Density (kg/m <sup>3</sup> @ 12% MC)	Calorific value (GJ/m <sup>3</sup> )	GYC	Rotation (yrs)	Yield over 50 yrs (Dry T/ha)
Eucalyptus	450 - 700	12.5	20+	10	>750
Ash	689	12.4	8	20	370
Birch	673	12.1	6	20	250
Sycamore	561	10.1	8	20	350
Alder	513	9.2	10	15	250
Larch (JL)	481	9.1	10	20	210
Aspen	480	8.6	12	15	280
Nothofagus	465	8.4	18 ?	15	590
Sitka	384	7.3	16	20	360
Willow (SRC)	430	7.7		3	400

Source: Forestry Commission, 2011

# Scenarios & Assumptions for LCA

- **Reference system, for SRF LCA comparison**
  - Bioenergy from conventional forest & industrial residues
- **Land use change (LUC)**
  - Conversion of marginal agricultural land to SRF
- **Harvest options:**
  - Conventional forest (Sitka spruce) thinning's and brash/residues
  - SRF stems only
  - SRF whole-tree
  - SRF whole-tree + stumps
- **Transport options:**
  - On-site mechanical forwarding to wood-chipper, set at 250 and 500 m
  - Off site haulage of woodchips (@ 50% MC), set at 50 and 100 km
- **Combustion options:**
  - Electricity generation at EPL – 35% efficiency
  - CHP at commercial site – 80% efficiency

# ShortFor LCA: Nursery seedling process

openLCA 1.4.2

File Window Help

Navigation

- bioenergiedat
- ecoinvent3\_1\_allocation\_default\_System\_and\_Unit\_data
  - Projects
    - MC-ShortFor v1
  - Product systems
    - MC SRF Product System - production of 2 yr old Eucalyptus nursery p
  - Impact assessment methods
  - Processes
    - A:Agriculture, forestry and fishing
    - B:Mining and quarrying
    - C:Manufacturing
    - D:Electricity, gas, steam and air conditioning supply
    - E:Water supply; sewerage, waste management and remediation activi
    - F:Construction
    - G:Wholesale and retail trade; repair of motor vehicles and motorcycle
    - H:Transportation and storage
    - J:Information and communication
    - L:Real estate activities
    - M:Professional, scientific and technical activities
    - N:Administrative and support service activities
    - S:Other service activities
    - MC SRF Process #1 - production of 2 yr old Eucalyptus nursery plants
  - Flows
  - Flow properties
  - Unit groups
  - Sources
  - Actors
  - ecoinvent3\_1\_allocation\_default\_Unit\_data\_only
  - ecoinvent3\_1\_lcia\_methods
  - elcd
  - MCdata
  - needs
  - openlca\_lcia\_methods\_1\_5\_3

Welcome | MC-ShortFor v1 | MC SRF Product System - ... | MC SRF Process #1 - prod... | MC SRF Flow #1 - 2 yr old ...

## Process: MC SRF Process #1 - production of 2 yr old Eucalyptus nursery plants

Inputs

Flow	Category	Flow property	Unit	Amount	Un...	Default provider
phosphate fertiliser, as P2O5 - GLO	016:Support activi...	Mass	kg	K	no...	field application of c..
nitrogen fertiliser, as N - GLO	016:Support activi...	Mass	kg	N	no...	field application of c..
potassium fertiliser, as K2O - GLO	016:Support activi...	Mass	kg	P	no...	field application of c..
electricity, low voltage - IE	351:Electric power...	Energy	MJ	EnergyNursery	no...	market for electricit...
transport, freight, lorry 3.5-7.5 metric ton, ...	492:Other land tra...	Goods transport ...	kg*km	MassPlants*Tran...	no...	transport, freight, lo...
transport, tractor and trailer, agricultural - ...	016:Support activi...	Goods transport ...	kg*km	MassPlants*Tran...	no...	transport, tractor an...
tree seedling - RER	013:Plant propaga...	Number of items	Item(s)	1.0	no...	tree seedling produc..

Outputs

Flow	Category	Flow property	Unit	Amount	Uncertainty	Avoi
MC SRF Flow #1 - 2 yr old Eucalyptus nursery plants		Number of items	Item(s)	Amt	none	

General information | Inputs/Outputs | Administrative information | Modeling and validation | Parameters | Allocation | Process costs

# LCA systematic procedures: Uncertainty & Sensitivity Analyses

- **Uncertainty analysis**

- Quantifying the uncertainty in the LCI results due to the cumulative effects of model imprecision, input uncertainty, and data variability.
- E.g., field emissions are highly dependent on LUC, local climate, soil properties, and site management practices.

- **Sensitivity analysis**

- Estimating the effects of the choices made regarding methods and data on the study results.

# In conclusion

## Overall aim of the project:

- To evaluate the GHG balance of SRF through LCA to see if it can positively contribute to our renewable energy goals – 16 % by 2020.

## Relevance to Sustainable Land Use:

- Biomass production is an ecosystem service

## Acknowledgements:

- Project funding provider – DAFM
- My supervisor – Dr. Ken Byrne
- ShortFor project partners: UCD, WIT, Coillte, Teagasc, TCD.

Thank you for your attention.