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National Forest Inventory of Ireland

Data processing methods

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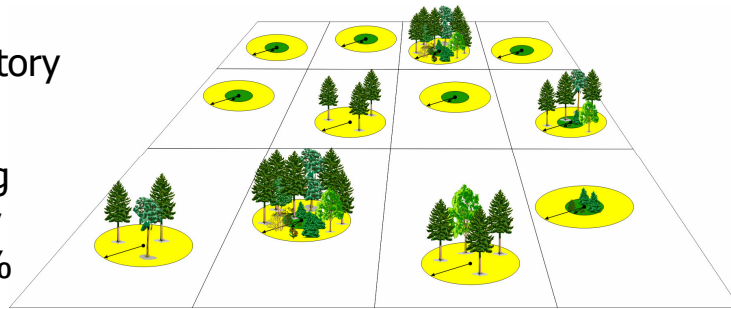
Content

1. Data processing basis – NFI design
2. Pre-processing – secondary attributes
3. Statistical data processing
4. Technology for data processing
5. Further possibilities of data processing

Data processing basis – NFI design

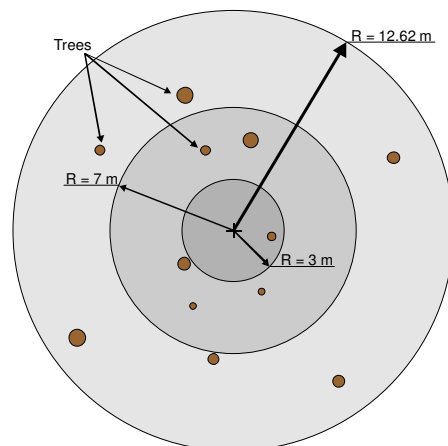
Statistically representative randomized regular grid of inventory plots

- 17,417 of inventory plots
- sampling intensity 0.0125%
- 1,742 forest plots



Data processing basis – plot design

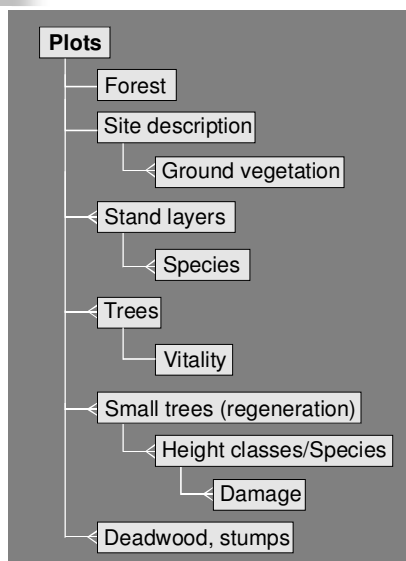
- Permanent circular inventory plots 500 m²
- Concentric circles (R=3-7-12.6 m; DBH=7-12-20 cm)
- 170 primary attributes
- Mapping of tree positions
- 24,946 recorded trees i.e. 16.0 per plot in average



Data processing basis - computer aided field data collection



Data processing basis - NFI database



Database:

29 tables
170 primary attributes
400 attributes in total
(primary+secondary)



Pre-processing of data



Methods of data pre-processing

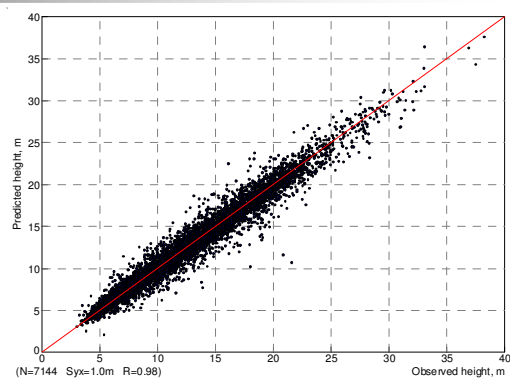
- **Modeling** (e.g. tree volume, biodiversity indices)
- **Classification** (e.g. diameter classes)
- **Aggregation** (e.g. number of species per plot)
- **Re-classification** (e.g. species groups)
- **Post-stratification** (e.g. by counties)

Tasks of data pre-processing

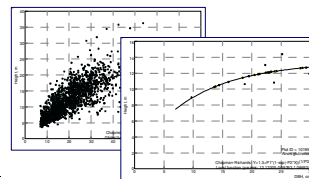
1. Tree heights
2. Timber volume
3. Tree biomass, carbon content
4. Virtual trees from regeneration
5. Representative area of a tree
6. Biodiversity indicators
7. Classification
8. Re-classification, species groups
9. Aggregation
10. Stratification

Modeled tree heights

- 33.6% of measured trees
- Non-linear and linear regression models parameterized using NFI data

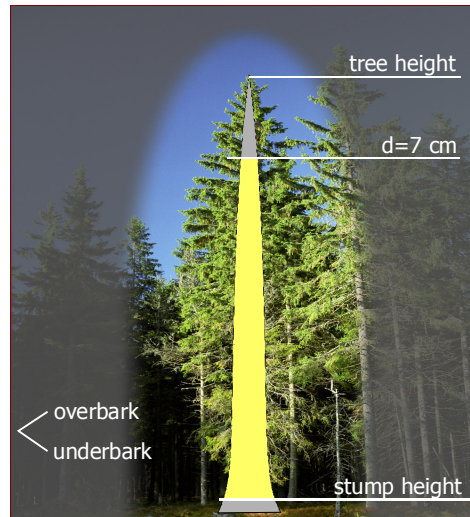


Model	Equation
exponential (Chapman-Richards)	$h = 1.3 + P_1 \times \left(1 - e^{-P_2 \times dbh}\right)^{\frac{1}{P_3}}$
exponential	$h = 1.3 + e^{\frac{P_1 + P_2}{dbh}}$
logarithm	$h = 1.3 + P_1 + P_2 \times \ln(dbh)$



Timber volume calculation

- Single tree models (volume calculated for every sample tree)
- British Forestry Commission Tariffs
- Irish national models



Timber volume by assortments

- Proportion of pulp, pallet, sawlog volume based on tree DBH
- Adjusted for stem quality attributes
 - Stem straightness
 - Stem break
 - Stem fork

BFC_Vol_Assortments	DBH	PULP	PALLET	SAWLOG
1	7	100	0	0
2	8	100	0	0
3	9	100	0	0
4	10	100	0	0
5	11	100	0	0
6	12	100	0	0
7	13	100	0	0
8	14	76	24	0
9	15	58	42	0
10	16	45	55	0
11	17	36	64	0
12	18	30	70	0
13	19	25	75	0
14	20	21	65	14
15	21	18	55	27
16	22	15	47	38



Tree biomass, carbon content

- Biomass components
 - Belowground biomass
 - Aboveground biomass
 - Total biomass
- Allometric equations compiled by Dr. Kevin Black (dry matter of biomass by species, dimension class, DBH and tree height)
- Carbon content (46% of biomass)

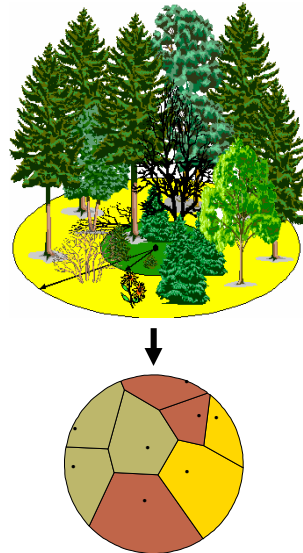


Virtual trees from regeneration

- Trees with DBH ≥ 7 cm recorded individually
- Regeneration trees ($h > 0.2$ m ... DBH < 7 cm) recorded by species and dimension class
- Complete tree table for data processing comprises all trees ($h > 0.2$ m) –tree of all dimensions are included into data processing

Representative area of a tree

- Area of the inventory plot is distributed among the trees
- Representative area of the tree is proportional to its size
- Representative area becomes an attribute of the tree and may be used for further processing



Biodiversity indicators

- Non-spatial indicators – diversity by species and dimensions
- Entropy (by species, growth stage)

$$H = \sum_{i=1}^n \frac{S_i}{S} \times \ln \left(\frac{S_i}{S} \right)$$

- Simpson index

$$I = \sum_{i=1}^n \left(1 - \frac{S_i}{S} \right) \times \left(\frac{S_i}{S} \right)$$

Classification

- Continuous data into discrete classes
- e.g. DBH into diameter classes, age into age classes etc.

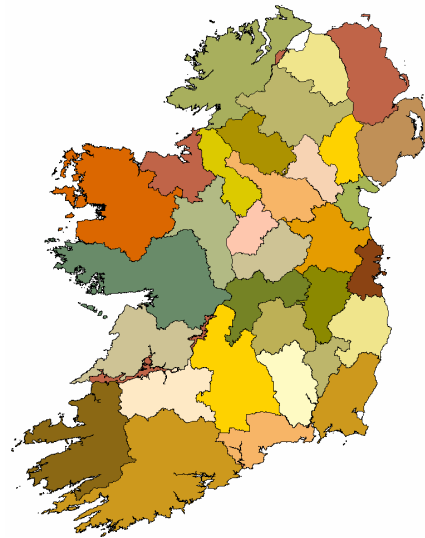
Re-classification, species groups

- re-grouping classes

Species group	Species
1 Sitka spruce	sitka spruce
2 Norway spruce	Norway spruce
3 Scots pine	Scots pine
4 other pine spp.	lodgepole pine, Austrian pine, Monterey pine
5 Douglas fir	Douglas fir
6 larch spp.	European larch, Japanese larch, other larches
7 other conifers	silver fir, grand fir, noble fir, cedar of Lebanon, Lawson cypress, coast redwood, vev , western redcedar , western hemlock
8 sessile and pedunculate oak	sessile oak, pedunculate oak
9 beech	beech
10 ash	ash
11 sycamore	sycamore
12 birch spp.	silver birch
13	downy birch
14 alder spp.	alder
15 other long living broadleaves	field maple, maple, horse chestnut, Strawberry tree, hornbeam, sweet chestnut, holly, notofagus sp., white poplar, black poplar, Turkey oak, pin oak, whitebeam, small-leaved linden, large-leaved linden, wych elm
16 other short living broadleaves	crab apple, aspen, Mazzard cherry, Wild cherry, blackthorn, goat willow, other willows, mountain ash, hazel

Stratification

- Less variability within strata → more accurate estimate of statistics
- Post-stratification
- Counties



Statistical data processing



Statistical data processing tasks

Basic terms:

1. **Evaluated variable**
(area, volume, number of trees)
2. **Stratifier**
(post-stratification decreasing variance)
3. **Classifier**
(species, diameter classes, soil groups, etc.)



Calculated statistics

- **Totals**
(total area, total volume, etc.)
- **Mean values**
(mean volume, mean height, mean defoliation, etc.)
 - Mean of totals
 - Mean of means
 - Mean of weighted means
 - Normalized mean of totals
 - Normalized mean of weighted means
- **Confidence interval for $\alpha=0.05$**

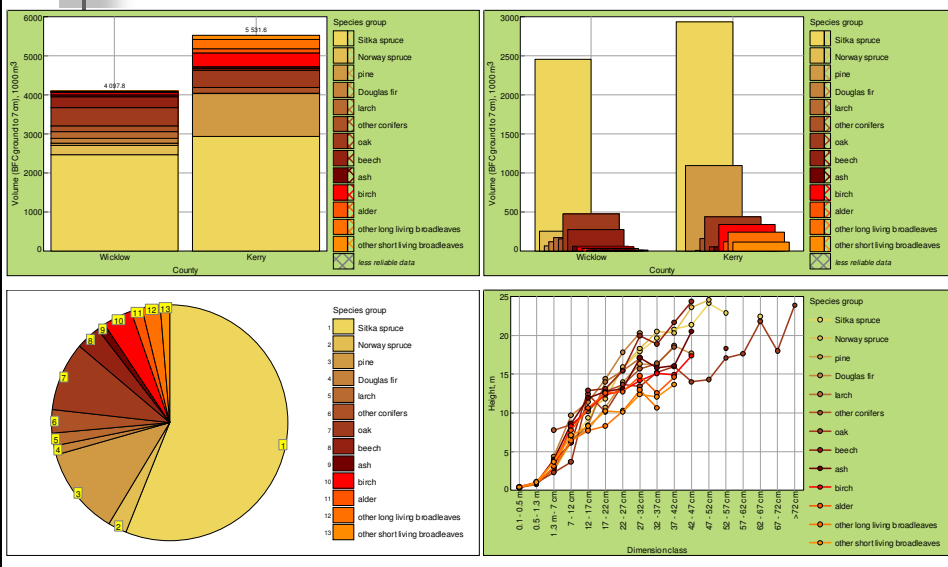
Standardized outputs (tables)

Classes Calculated statistics (total) Confidence interval Percentage

Species group	County / Volume (BFC ground to 7cm)								
	Wicklow			Kerry			Total		
	1000 m ³	($\alpha = 0.05$)	%	1000 m ³	($\alpha = 0.05$)	%	1000 m ³	($\alpha = 0.05$)	%
Sitka spruce	2 458.7	(1 628.8 – 3 288.5)	59.9	2 938.1	(2 126.6 – 3 749.6)	53.1	5 396.8	(4 266.2 – 6 527.3)	56.0
Norway spruce	248.7	(0.0 – 2 861.9)	6.1	–	–	–	248.7	(0.0 – 2 861.9)	2.6
pine	60.2	(0.0 – 143.1)	1.5	1 095.4	(0.0 – 2 377.2)	19.8	1 155.5	(0.0 – 2 438.1)	12.0
Douglas fir	116.9	(0.0 – 302.5)	2.9	–	–	–	116.9	(0.0 – 302.5)	1.2
larch	168.6	(0.0 – 346.9)	4.1	2.8	–	0.05	171.4	(0.0 – 349.7)	1.8
other conifers	149.6	(86.4 – 212.7)	3.7	155.5	(0.0 – 1 257.8)	2.8	305.1	(0.0 – 1 409.1)	3.2
oak	468.8	(63.7 – 873.9)	11.4	438.3	(159.6 – 716.9)	7.9	907.1	(445.5 – 1 368.6)	9.4
beech	272.9	(0.0 – 577.7)	6.7	50.8	(0.0 – 164.1)	0.9	323.7	(1.4 – 646.0)	3.4
ash	56.6	(8.0 – 105.2)	1.4	48.7	(10.4 – 87.1)	0.9	105.3	(43.4 – 167.2)	1.1
birch	50.5	(0.0 – 147.6)	1.2	336.5	(67.2 – 605.8)	6.1	387.0	(116.0 – 657.9)	4.0
alder	30.6	–	0.7	118.0	(55.5 – 180.6)	2.1	148.7	(86.1 – 211.2)	1.5
other long living broadleaves	7.6	(0.0 – 15.5)	0.2	235.3	(20.5 – 450.0)	4.3	242.8	(28.1 – 457.6)	2.5
other short living broadleaves	8.3	(0.0 – 29.8)	0.2	112.1	(16.1 – 208.2)	2.0	120.5	(24.3 – 216.7)	1.3
Total	4 097.8	(3 094.9 – 5 100.7)	100.0	5 531.6	(4 110.0 – 6 953.2)	100.0	9 629.4	(7 909.7 – 11 349.1)	100.0

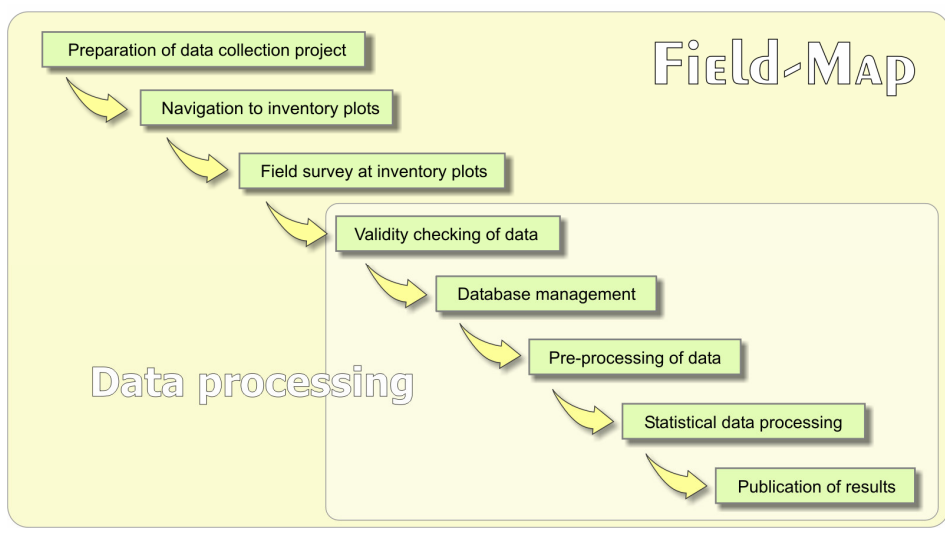
Totals, sub-totals

Standardized outputs (charts)

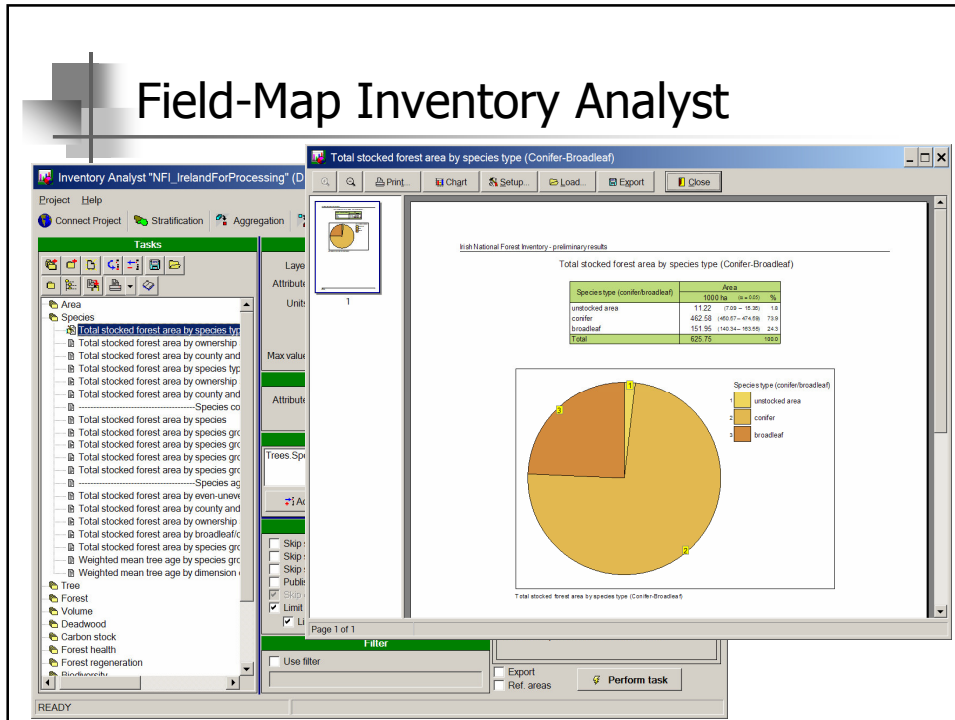


Data processing technology

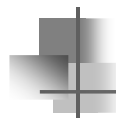
Comprehensive technology for NFI



Field-Map Inventory Analyst



Further possibilities



Data processing possibilities

1. Regionalization
2. Forecasting
3. Specific tasks of the scientific analysis



Regionalization

- Irish NFI provides data for the country level
- County data can be evaluated with limited accuracy
- Results for local forest managers ?



Regionalization options

- **Modeling approach**
(generalization of NFI information in form of models and application elsewhere)
 - Spatial modeling (GIS: geostatistical techniques such as co-kriging)
 - Regression modeling (“cause-effect” models enabling to calculate broader set of variables based on limited local information)
- **Denser inventory grid for regions (counties)**
(operational statistical forest inventory)



NFI potential for forecasting

- Current increment data (at least one repeated inventory) = inventory of current increment
Evaluation of cutting possibilities (quantity & quality)
- Forecasting
requires combination of NFI data with a model (e.g. growth and yield model)
- Model development
 - Model parameterization using NFI data
 - Formulation of new models

Stand level models / virtual stands

