Soil and Site Indicators for the Production of High Quality Ash *(Fraxinus excelsior* L.)

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• The opportunity to discover relationships between environmental factors and tree growth and hence, the ability to evaluate variation in forest site productivity has been an area of continuing interest in forest research for many years.

• Diversification of species is meaningless if species are not correctly matched to site. The current increasing emphasis on species diversification in Irish forests, along with a greater availability of more fertile land for forestry and the higher grants and premia for broadleaves, means that there is a need for the same research into site suitability for broadleaves as was originally carried out for species such as Sitka spruce (*P. sitchensis* (Bong.) Carr).

• In this study, the productivity of a number of ash crops throughout the country was assessed. Soil and site variables for each crop were measured and attempts were made to determine which variable was responsible for causing the greatest variation in ash growth.

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Background

High quality ash (*F. excelsior* L.) is an ideal substitute for imported hardwoods. However, it is a species which has not been studied in any great detail in Ireland. Ash is widely reported to be very exacting in its site type requirements. Therefore, in order to achieve high quality ash crops the potential to predict productivity on land available for planting is essential.

The main aims of this study were:

- to determine the relationship between soil and site factors and the growth of ash;
- to produce a model which would primarily be used as a tool to assist in species selection decisions. In order to be of practical everyday use, this type of model should ideally contain only two or three site variables which explain a large proportion of the variation in site productivity. These variables should be easily and inexpensively measured.

In this study, observed tree growth - which reflects the response of the crop to various environmental site factors - was used as a measure of site productivity.

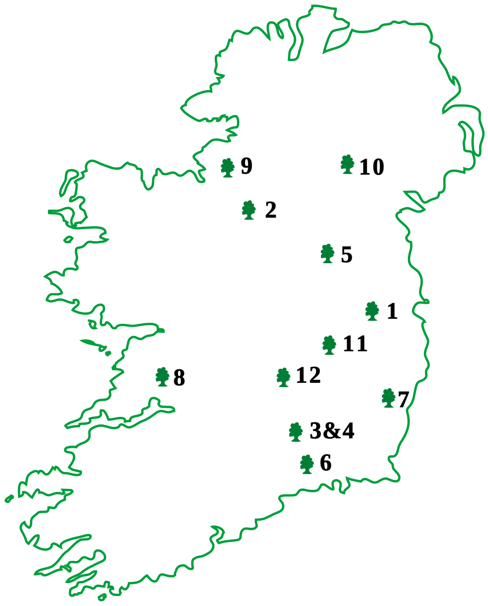
Methodology

An initial study area of 23 ash stands, from various forests throughout the country, was selected from a database provided by Coillte. Following inspection of these original stands, twelve were eventually sampled (Figure 1). All stands sampled were above 0.5 hectares (ha) in size and between 20 and 60 years of age; those in mixture with another species contained at least 70% ash. Although it is ideal to sample fully stocked stands for this type of study, a number of stands included were poorly stocked. This occurred for various reasons including; lack of management in some of the smaller stands and harvesting for hurley butt material in a number of the others. As there are no records of silvicultural or management practices for these crops, the effects of such treatments on crop quality could not be assessed.

The crops growing on the selected sites were evaluated by measuring a range of parameters (Table 1). These parameters, i.e. yield class (YC), basal area and volume per hectare, were chosen as estimates of crop quality because they are

[1]In this study the term 'site' as applied to an area of forest land, includes but does not specify the prevailing flux of environmental conditions.

[2] A more detailed report is presented in the COFORD publication 'Soil and Site indicators for the Production of High Quality Ash (Fraxinus excelsior L.)'



No.	Forest	No.	Forest
1	Allen	7	Coolgreaney
2	Arigna	8	Ennis
3/4	Callan	9	Lough Gill
5	Castlepollard	10	Monaghan
6	Comeragh	11	Rathdangan
		12	Templemore

Figure 1. Locations of ash stands sampled.

all influenced predominantly by site type. Random soil samples were taken at each site for both mechanical and chemical soil analysis. Undisturbed samples were removed to the laboratory for moisture availability determinations. Loose soil samples were taken for nutrient, pH and particle size analyses. Increment cores were taken from top height trees, in order to assess annual increment. Average May/June rainfall for each site were calculated from the meteorological data available. Site elevation, aspect and exposure were also assessed at each site.

Statistics

Multiple regression models, to determine site productivity, were derived by stepwise regression of measured edaphic, climatic and topographic data on crop quality. The multiple regression models derived in this study are in the form:

$Y = a_0 + a_1X_1 + a_2X_2 = a_nX_n$

where:

Y = dependent variable

X_n = independent/site variable

a_n = corresponding regression coefficient

The fact that no management records were available for the crops sampled was an important factor to be taken into consideration when choosing a measure of crop quality. Yield class was chosen as this estimate because it is 'the maximum mean annual increment which a given crop can achieve, on a particular site, irrespective of treatment'.[3] Basal area and volume per hectare are influenced by stocking levels and hence management practices. In this type of study it is desirable to have as wide a range of crop quality estimates, i.e. yield classes (YC), as possible. However, only crops of YC 2, 4 and 6 were found.

Table 1: Estimates of crop productivity.

Forest	Planting Year	Yield Class	Mean Basal Area (m^2/ha)	Volume/hectare (m^3/ha)	Mean Top Height (m)
Allen	1939	6	15.3	115	18.7
Arigna	1951	2	39.0	190	13.2
Callan	1952	6	33.5	230	17.3
Callan 3	1965	4	17.8	80	12.6
Castlepollard	1936	4	24.0	186	16.0
Comeragh	1966	2	16.2	37	9.5
Coolgreaney	1958	2	22.8	92	11.8
Ennis	1951	2	25.7	82	10.6
Lough Gill	1940	6	18.5	140	18.5
Monaghan	1974	6	12.1	42	10.8
Rathdangan	1950	2	24.9	105	12.2
Templemore	1950	2	19.8	75	11.5

[3] *Edward, P.N. and Christie, J.M. (1981). Yield Models for Forest Management. Forestry Commission Booklet No. 48.*

A database was created containing all of the information that was collected at each of the study sites (Table 2). Using stepwise regression analysis a model for the growth of ash was derived based on the information contained in this database.

It is important to recognise that tree growth is not a reflection of any single particular soil or site variable. It is the combined influence of many of these variables which actually effects growth. Therefore, correlation matrices were also produced in order to examine any relationships between these independent variables.

Results

Stepwise Regression Analysis

Stepwise regression analysis of the complete database containing all of the YC 2, 4 and 6 site data produced Model 1. This model indicated that extractable phosphorous (P) was the only independent variable which significantly affected ash growth, accounting for 33 % of the variation on these sites.

It was then decided to remove YC 2 sites from the data base and run the stepwise regression procedure on the remaining YC 4 and 6 site data. YC 2 sites were omitted on the basis that sites achieving such low yield classes are probably unsuitable for the growth ash and should possibly not have been planted with that species.

Model 1

YC (m^3/ha/year) = **2.43** + **0.17 P (µg/g)**

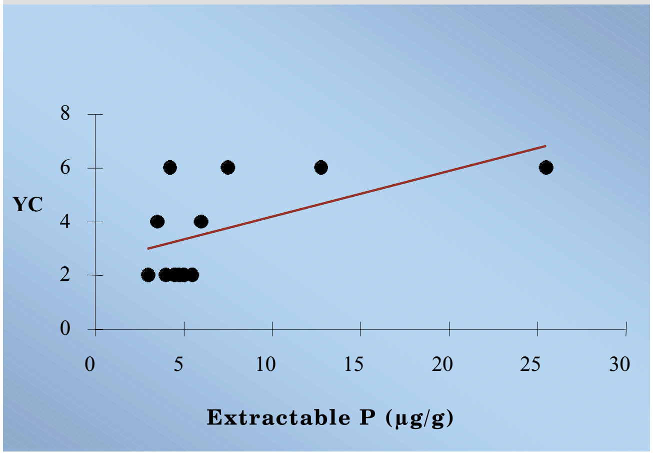


Figure 2. Regression line fitted to the measured yield classes for Model 1.

Model 2, derived by stepwise regression using the YC 4 and 6 sites, showed that percentage sand content of the soil was the only independent variable which significantly affected ash growth, explaining 64% of the variation on these sites.

Table 2: Average (mean) and range of values for dependant and independent variables.

Factor	Unit	Mean	Maximum	Minimum
Yield Class (YC)	m^3/ha/year	3.67	6.00	2.00
Average May/June rainfall	mm	63.19	77.90	54.00
Sand	% by wt.	42.63	54.60	17.70
Silt	% by wt.	30.75	44.50	18.30
Clay	% by wt.	26.61	41.40	14.00
Surface available moisture content	% by wt.	48.97	74.60	31.70
Subsoil available moisture content	% by wt.	39.03	67.20	18.10
Total nitrogen	% d.m.	0.53	0.78	0.35
Extractable phosphorous	µg/g	7.19	25.50	3.00
Extractable potassium	µg/g	127.22	277.25	61.25
Extractable magnesium	µg/g	270.40	425.25	146.50
Extractable calcium	µg/g	2,557	6,402	626
Elevation	Feet	260.67	400	25
Surface pH	pH unit	5.5	4.7	6.8
Subsoil pH	pH unit	5.4	4.7	7.5
Age	years	42	59	21

Model 2
YC (m^3/ha/year) = **2.39 + 0.06 Sand %**

Independent Variable Correlations

Analysis was carried out to examine the relationships between the independent variables. Some of the significant correlations highlighted were those which would be expected to occur, such as correlations between elevation and aspect. Other correlations were not quite as obvious, such as the significant relationship between aspect and extractable potassium (K). However, a correlation between two variables is merely a relationship that occurs between them. It can not necessarily be deduced that the variables influence each other in any way. It is possible that both may be affected by a third variable.

In Model 1, the concentration of extractable P was the independent variable found to have the greatest influence on YC. In the correlation matrix for this dataset no other independent variables were found to be significantly correlated with extractable P.

In Model 2, percentage sand was the independent variable which was found to have the greatest influence on YC. In the correlation matrix for this dataset significant correlations were found between percentage sand and both concentration of extractable calcium and concentration of extractable magnesium.

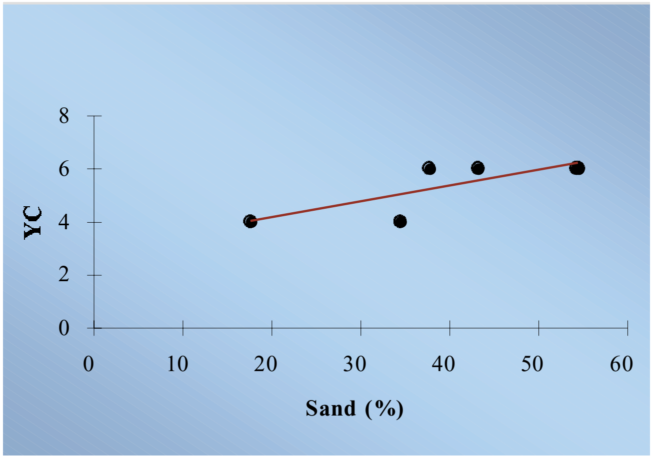


Figure 3. Regression line fitted to the measured yield classes for Model 2.

Conclusions and Recommendations

• A number of limitations were imposed on this study, including the small number of suitable sites available for sampling as well as the small range in yield classes of these sites. However, in general terms the final model indicates that on sites with soils containing high levels of sand, ash crops will achieve higher rates of productivity. Obviously there will be a cut off point where the proportion of sand to silt and clay in a soil is so high that it produces an adverse effect on ash growth. Since this model was derived using only YC 4 and 6 sites, this situation was not encountered. Therefore, it is not wise to presume that this model can be accurately applied when predicting higher yield classes of ash growth. When validating any model derived in this manner, the use of an independent dataset is critical. However, due to a combination of constraints and the lack of suitable sites, this was not possible in this study.

• Although producing a model with a small number of independent variables which would accurately predict the potential yield of a site would be of great benefit, it is not always this straightforward. Interactions occur between the different independent variables and it may very often be the combined effect of several variables which influence crop growth rather than just one particular variable on its own.

• It is recommended that this study be used as a starting block for a much more detailed investigation into site suitability for ash. By identifying a larger range of suitable ash crops, in particular ones of higher YC, further soil analysis could be carried out to validate the models presented in this report.