Preliminary estimates of biomass carbon stock changes in managed forests in the Republic of Ireland over the period 1990-2000

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Abstract

National reporting requirements to the United Nations Framework Convention on Climate Change on carbon sequestration in forests and harvest include estimates of changes in biomass stock in the forest estate over time. Incomplete inventory records have meant that yearly records of total forest increment were not available. A time series was constructed for Irish forests for the period 1990-2000 using forest area categories defined in the forest inventory and planning system of the Forest Service. These data were supplemented by planting and felling data. Carbon stock changes are presented for the year 2000 and show a net increase of 160,000 t of carbon after harvest. Calculations are carried out in a flexible spreadsheet model which can be updated as new data on biomass expansion factor comes to hand.

Key words: Biomass, carbon stocks, UNFCCC, sink

Introduction

Forest vegetation is a major component of the global carbon (C) cycle and is estimated to store at least 350 Pg C (Dixon et al. 1994). This is subject to increase or decrease as a result of factors such as harvest, re-growth, conversion to other land uses, with resulting changes in C fluxes to the atmosphere. There is an ever-increasing need to improve the accuracy of estimates of C storage in forest biomass so that its role in the global C cycle can be characterised and understood. The advent of the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol have also added impetus to the need for such information.

Forest inventory data, in combination with yield models are is the most practical means for estimating biomass C stocks and changes. Yield models have the advantage that they can be used for different age classes and forest types. However, they should reflect potential changes in growth as a result of changing climatic and environmental conditions and may therefore need updating.

Carbon removals can be estimated using harvest statistics. However, forest inventory is usually only concerned with the merchantable stemwood volume. Therefore, estimates of biomass C stock need to take into account the non-stemwood biomass components such as braches, foliage, stumps and roots. This is commonly done using biomass

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expansion factors (BEFs), which express the ratio of merchantable biomass to total biomass.

Carbon accounting methods for Irish plantation forests are at an early stage of development. The first published assessment of biomass C stocks in Irish forests was by Kilbride et al. (1999). Since then the policy framework has continued to develop with the publication of the National Climate Change Strategy (Department of the Environment and Local Government 2000) and Ireland's ratification of the Kyoto Protocol in 2002.

In 2000, following a request from the UNFCCC for additional information on net carbon uptake in forests in the Republic of Ireland during 1998, COFORD (the National Council for Forest Research and Development) commissioned a study to estimate carbon increment and carbon removed in harvesting during that year (Gallagher 2000, COFORD 2001). This was followed by a request from the Forestry Climate Change Team of the Department of Communications, Marine and Natural Resources to develop an annual time series of C stocks in Irish forests over the period 1990 to 2000 which would form a baseline for forest C accounting in the Republic. This paper reports on the approaches used to determine these statistics.

Materials and methods

Data sources

Data were assembled from a number of sources. Forest inventories have been carried out in state owned forests since the 1950s (O'Flanagan 1973). In 1989 the Irish state involvement in forestry underwent a radical change resulting in the formation of two organisations: the Forest Service, the statutory authority responsible for forestry administration and Coillte, the Irish Forestry Board a state sponsored company owning and managing the public forests. While the last inventory of private forests was carried out under the Forest Service as far back as 1973 (Purcell 1979), Coillte's inventory covers all their forest areas and is updated regularly. Coillte also records information on its thinning and felling harvests.

Since the late 1980s, privately owned woodland has become a very significant part of the national estate. It currently accounts for 39% of the total forest area (Hendrick et al. 2002). A full survey of all state and private forests was completed in 1996 under the Forest Service's Forest Planning and Inventory System – FIPS (Fogarty et al. 1999). It provides information on areas by species development category for all forests identified by remote sensing. The second phase of FIPS, a sample based inventory of standing volume, stocking and other variables commenced in 2003 with a pilot study in Co Wexford.

Private and state planting can be tracked through Forest Service recent internal reports (Forest Service 2000) and Ministers' reports on forestry (Ministers' Reports 1980-1988).

The United Kingdom (UK) Forestry Commission yield models (Hamilton et al. 1971) are reasonably reliable as a source of production data for plantation species grown in Ireland. Irish models are available for a limited number of species such as coastal lodgepole pine (*Pinus contorta* var *latifolia*) (Forest and Wildlife Service 1975), which still comprises a significant part of the national forest estate. Irish models have recently been constructed for Sitka spruce (Coillte 2003) and other species but they have not been fully validated yet and have, as yet, not been used for estimation of carbon stocks and increment.

Conversion factors relating wood volume to biomass and thence to carbon have been developed by the UK Forestry Commission (Hamilton 1975). These are in the range used by the Intergovernmental Panel on Climate Change (IPCC) (Houghton et al. 1996) and have been used in recent reports and studies on carbon storage in Ireland (Kilbride et al. 1999). In this paper the Forestry Commission factors for basic (dry) density are used in combination with IPCC default values for carbon content. BEFs used were those estimated by Black et al. (2004), which take into account age related changes in biomass distribution in Irish forests. These BEFs are higher than those used in previous national reporting to the UNFCCC (McGettigan and Duffy 2003) and, as they are based on sampled trees are considered to reflect better Irish forest conditions.

Carbon content of the national forest estate

The main problem in estimating carbon stocks and increment was to accurately model the development of the national forest estate given the relative paucity of quantitative data. Two approaches were considered:

1. To base the time 1990-200 time series mainly on Coillte inventory information and supplement this with largely speculative information for the private sector, or
2. To use FIPS data for the total forest estate, which are area based but lack wood volume and increment data for the different strata.

The second approach was used, supplemented with yield data from Coillte forests and using Irish and UK yield models to determine wood production and thence C stocks and stock changes in Irish forests.

Given that the FIPS database represents the national forest estate for year 1995 only, it was necessary to arrive at assumptions as to how it developed between 1990 and 2000. Another problem was that FIPS updates since 1995 include non-surveyed planting-grant-data in the different strata, so the basis of 1995 data and those of later years was different.

A time series of forest strata by age and area was constructed using the FIPS base year of 1995. This comprises recorded and interpreted information for identified forests. A considerable area of very young, cleared or unclassified (uninterpreted) forest is included in the 1995 data, and estimated in the time series as a separate category for information purposed. The latter had little impact on the contribution to carbon storage or stock changes over the period.

The three broad categories identified by FIPS are:

1. Cleared/unclassified (including young plantings),
2. Young crops and
3. Mature crops.

The latter two categories are further broken down into species categories to provide the individual strata (Table 1). Over time there is a movement from cleared areas to young to mature crops and back to cleared, as stands are planted or reforested, grow to maturity and are felled (Appendix 1). This is the pattern assumed in the model. How this movement takes place will be determined by the rates of afforestation, clearfelling and reforestation taking place prior to and during the series.

Table 1. *FIPS categories by area for 1995 and their relationship to the strata used to report to the UNFCCC.*

FIPS stratum	*Abbreviation*	*Area 1995 ha*	*Reporting stratum*
Conifer spruce young	CYS	92,407	*Picea*
Conifer larch young	CYL	1,031	Other coniferous
Conifer pine young	CYP	29,083	*Pinus*
Conifer pine/spruce young	YPS	10,575	*Picea* 50%, *Pinus* 50%
Conifer other young	CYO	7,101	Other coniferous
Broadleaf oak young	BYK	218	*Quercus*
Broadleaf beech young	BYB	161	*Fagus*
Broadleaf other young	BYO	6,055	Other broadleaf
Mixed young	MXY	4,480	Mixed broadleaf conifer forest
Conifer spruce mature	CMS	93,004	*Picea*
Conifer larch mature	CML	3,502	Other coniferous
Conifer pine mature	CMP	32,608	*Pinus*
Conifer pine/spruce mature	MPS	27,369	*Picea* 50%, *Pinus* 50%
Conifer other mature	CMO	9,453	Other coniferous
Broadleaf oak mature	BMK	5,600	*Quercus*
Broadleaf beech mature	BMB	3,072	*Fagus*
Broadleaf other mature	BMO	43,233	Other broadleaf
Mixed mature	MXM	24,479	Mixed broadleaf conifer forest
Other	O	1,900	Other forest
TOTAL FIPS COVER		395,331	
Cleared/unclassified [1]	CUC	180,777	Unclassified young forest plantations
TOTAL AREA IDENTIFIED BY FOREST SERVICE		576,108	

[1] This includes the FIPS cleared category and the balance of area to make up the Forest Service total area for 1995.

Carbon removals through harvesting

Coillte records (Coillte 2001) represent the main source of data for wood harvesting. These data are compiled through the company's timber sales reporting system and are available for the period since 1991. Detailed information is sparse for the private sector. In this instance recourse was made to a forecast of production for all forests in the Republic of Ireland (Gallagher and O'Carroll 2000) to estimate the private sector harvest.

Assumptions made in relation to the FIPS categories

Age

Cleared areas were assumed to include crops less than 7 years old. Young crops were assumed to include crops from 7 to 25 years old. Mature crops were assumed to include crops from 25 years old to year of final harvest.

Species categories

FIPS categories (Table 1) were regrouped into categories suitable for reporting in the format of the Table 5a categories in Houghton et al. (1996): *Quercus*, *Fagus*, Other broadleaves, *Pinus*, *Picea* and Other conifer (*Abies* is not classified and was therefore included with other conifers).

Yield prediction

The Coillte average weighted yield class (wood production model) was applied to all state and private sector forests for each of the FIPS species categories (Table 2). Young broadleaves were given representative yield class estimates based on expert knowledge.

Area

The FIPS 1995 areas were accepted as the baseline area for all strata except that classified as cleared (while accepting that the latter case would have included some very young grant-aided forests not identified by remote sensing as having forest cover). In this instance, the Forest Service figure, compiled from national statistics for the total

Table 2. *Yield classes assumed for the FIPS strata.*

FIPS stratum	*Yield class* $m^3 ha^{-1} yr^{-1}$
Spruce	16
Pine	10
Larch	8
Other conifers	14
Mature oak and beech	4
Other mature broadleaves	6
Young oak and beech	6
Other young broadleaves	8

forest area of a given year that year, minus the total of all the FIPS categories, plus the FIPS cleared category, was used to estimate the cleared/unclassified area (see footnote 4). Using this approach for the years from 1995 to 2000 allowed the forest area to grow to the total forest area estimated by the Forest Service, from all sources, for the year 2000. A fuller description of this methodology is outlined in Appendix 1.

Crop volume production

Volume was determined from the UK and Irish yield models (Hamilton et al. 1971, Forest and Wildlife Service 1975). Main crop volume after thinning was used in conifers. The ages assumed for young and mature conifers were 15 and 35 years respectively.

Young broadleaved crops were allocated a nominal standing volume of 10 m^3 ha^{-1}. In the case of mature broadleaved forests volume was determined from the total wood plus firewood volume recorded in forest estates during the last inventory of private woodlands (Purcell 1979), divided by area.

Mixed mature forest volume was based on the average of the mature other conifers and broadleaves strata.

Volumes were first allocated to the FIPS strata and were then redistributed by species x area categories to be used for reporting to the UNFCCC and converted to carbon equivalents (Table 3). Standing volume was reduced by 15% to allow for roads and rides. Average standing volumes for the UNFCCC categories changed each year (Appendix 2) as a result of area weighting when converting from the FIPS categories.

Change in forest areas over time

It was assumed that forest areas changed over time in the following manner:

1. Afforested and reforested[2] areas, as determined from Forest Service planting records and Coillte clearfell data, currently described as cleared, moved into the young category when they reached 7 years of age. The impact of deforestation was minimal in this period.
2. An equal percentage of young crops moved each year into the mature category. This percentage is related to the time span between the minimum and maximum ages defined for young crops. In this case (minimum age 7 years) the turnover is 18 years equivalent to 5.6% per year.
3. Clearfelled areas (assumed to equate to, and occur the year prior to, reforestation) together with an estimated 200 ha^{-1} yr^{-1} for the private sector, moved each year from the mature to the cleared category.
4. An exception was made for mature oak and beech where, because of increasing constraints on clearfelling of broadleaves, no clearfelling was assumed over the period (1990 – 2000).
5. Clearfelling was allocated to strata on the basis of their FIPS mature category distribution.

[2] Reforestation is regeneration after felling, not planting of former forest land that has been converted to agriculture or another land use, which latter is the Marrakesh Accords definition.

Table 3. *Standing volume and conversion factors used for the FIPS strata.*

FIPS statum	*Standing volume*	*Reduced Volume*	*Biomass expansion factor (BEF)*	*Dry (basic) density*	*Carbon content*	*Carbon*
	$m^3\ ha^{-1}$			$t\ m^{-3}$		$t\ ha^{-1}$
(a)	*(b)*	*(c)= b x 0.85*	*(d)*	*(e)*	*(f)*	*(g) =c x d x e x f*
CYS	57	48.5	2.0	0.350	0.5	16.975
CYL	46	39.1	2.0	0.440	0.5	17.204
CYP	40	34.0	2.0	0.400	0.5	13.600
YPS	48	40.7	2.0	0.375	0.5	15.263
CYO	52	44.2	2.0	0.400	0.5	17.680
BYK	10	8.5	2.0	0.550	0.5	4.675
BYB	10	8.5	2.0	0.550	0.5	4.675
BYO	10	8.5	2.0	0.550	0.5	4.675
MXY	30	25.5	2.0	0.480	0.5	12.240
CMS	256	217.6	1.4	0.350	0.5	53.312
CML	206	175.1	1.4	0.440	0.5	53.931
CMP	190	161.5	1.4	0.400	0.5	45.220
MPS	221	187.7	1.4	0.375	0.5	49.271
CMO	233	198	1.4	0.400	0.5	55.440
BMK	255	216.7	1.4	0.550	0.5	83.430
BMB	256	217.6	1.4	0.550	0.5	83.776
BMO	160	136	1.4	0.550	0.5	52.360
MXM	175	148.8	1.4	0.480	0.5	49.997
O	150	127.5	1.4	0.550	0.5	49.088

To estimate the rate of change prior to 1995, the process was worked in reverse (see Appendix 1).

Determining carbon stocks and harvest

Total carbon content was determined as:

basic density x carbon content (for the different species based on Hamilton 1975 and Houghton et al. 1966) x biomass expansion factor (BEF) (Black et al. 2004).

This calculation was used to convert the reduced timber volume to carbon (Table 3). Carbon storage in the FIPS categories was then converted to the categories to be used for reporting to the UNFCCC (Table 4 and Appendix 2).

In the guidelines on methods for reporting changes in carbon in forest biomass stocks (Houghton et al. 1996 Table 5a), increment values are used to determine annual increments in carbon stocks and from these the harvest is subtracted to find the net changes in carbon stocks. (This is analogous to Article 3.4 of the Kyoto Protocol, which can be paraphrased as: human induced net changes in carbon stocks). Here we modified the table to use reduced actual standing volumes (less thinning) on a net area basis to estimate standing volume. Increment was then calculated by subtracting from the carbon stock in year n the carbon stock in year n-1. This is the increment in stock less the harvest, as the thinning volumes have already been removed from the data used, and the areas are net of clearfelled volumes.

In order to compare stock changes derived from the model with those presented in the common reporting format the annual wood harvest volume which was estimated independently from Coillte and private sources was converted to carbon using the same conversion factors. The harvested volume includes firewood, which is estimated to be in the region of 30,000 m^3 yr^{-1} (Appendix 2). (Carbon dioxide emissions from the use of firewood are estimated but not reported under the general reporting format as the process is assumed to be carbon-neutral (Duffy 2003)).

Results

Carbon stocks in the national forest increased by an estimated 2.3 Mega tonnes[3] (15.9 to 18.2 M t C) over the period 1990 to 2000 (Table 4). When carbon removed in harvest is added to the net annual increase in forests after thinning, the gross carbon stock change increased from 0.73 M t C to 1.2 M t C over the period. This was despite an annual harvest which increased from c. 0.51 to 0.91 M t C over the same period (Figure 1).

The average annual net increase in carbon stocks over the eleven years was 0.23 M t C. This had increased to 0.28 M t C by 1998, decreasing to 0.21 M t C in 1999 and recovering to 0.26 M t C in 2000. Overall the rise has been uneven, probably reflecting changing patterns in planting and increases in clearfelling. The impact of lower rates of new planting in the mid 1980s on the movement of cleared/unclassified areas to young

Table 4. *Carbon stocks, harvest and net changes in stocks over the period 1991-2000.*

Year	*Standing carbon stock*	*Carbon stock change*	*Harvest*	*Net carbonstock change*	*Harvest as a percentage of annual increment*
		Mt C			*%*
1990	15.887	0.725	0.509	0.216	70
1991	16.114	0.764	0.537	0.227	70
1992	16.299	0.818	0.632	0.186	77
1993	16.508	0.847	0.638	0.209	75
1994	16.708	0.894	0.694	0.200	78
1995	16.928	0.943	0.723	0.219	77
1996	17.146	0.967	0.748	0.219	77
1997	17.397	0.956	0.705	0.251	74
1998	17.679	1.083	0.801	0.282	74
1999	17.885	1.049	0.843	0.206	80
2000	18.145	1.174	0.913	0.260	78

[3] One Mega tonne is one million tonnes.

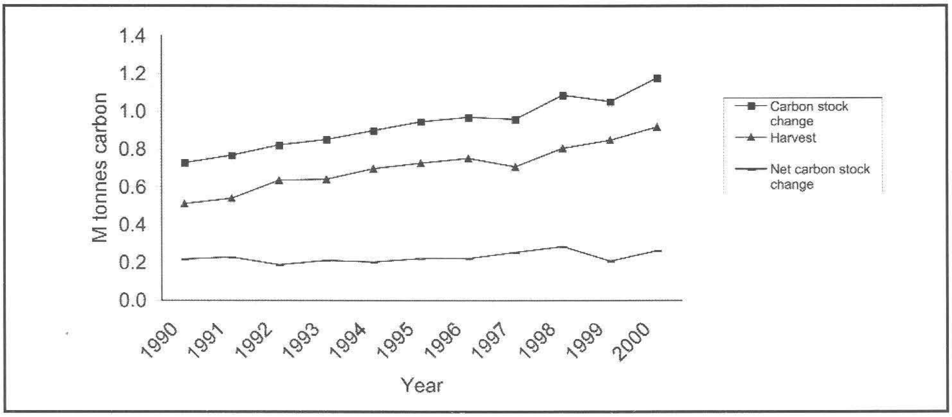

Figure 1. *Comparison between wood harvest and net carbon stock change in Irish forests over the decade 1991-2000.*

crops, and the movement of mature crops to cleared, has probably resulted in this fluctuating pattern, although the carbon stock of the total forest estate continues to increase as a result of the afforestation programme. The very high rates of planting in the mid 1990s had not made a significant impact on carbon stocks or increment by the year 2000. These areas would only start to move from cleared/unclassified to young crops during this period. Overall it is estimated (Table 4 that between 70% and 80% of the carbon stock increment was removed in harvesting.

It is of interest to note that the difference between gross increment and cut for the national estate was 0.28 M t C or 74% compared with 0.13 M t C or 87% reported by Coillte for the year 1998 (Coillte 1999) on the basis of the conversion factors used.

The model indicates a considerably higher total forest carbon store in the Republic for the year 2000 (18.2 M t C) than the 10.7 M t C reported by Cruickshank et al. (2000) on the basis of CORINE land cover (including scrub and discontinuous trees). The model described here excluded areas of young plantation not identified by remote sensing and assumed a higher carbon content fraction than Cruickshank et al. (2000), although the basic densities and BEFs are similar. Some of the scrub, which was derived from the 1971 inventory of private woodlands (Purcell 1979), will have disappeared through clearance and land reclamation. Some will have been recorded by FIPS as broadleaved forest. The average forest biomass carbon stock in our model for the year 2000 was 39.6 t C ha^{-1} for the productive areas of forest estimated by Cruickshank et al. (2000) or 24.7 t ha^{-1} when the areas of scrub and discontinuous trees (taken from the Corine classification) are included.

Discussion

The higher carbon storage estimates for the Republic determined here compared with those in Cruickshank et al. (2000) warrants further comment. The higher per ha carbon stock may be explained by the use of 0.5 as the carbon fraction of dry wood biomass (IPCC 2004) compared with a range of 0.42 – 0.46 used by Cruickshank et al. (2000).

The area of young and mature forest in the present approach for 2000 is 0.459 m ha and all classified forest land is 0.650 m ha compared with the CORINE area of 0.299 m ha productive forest and 0.432 m ha of forest, scrub and discontinuous trees. These differences would therefore explain the significantly greater total carbon stock for the year 2000 reported here. A more detailed breakdown of species may have also contributed to this result. Overall it would appear that, for the options assumed here, the time series gives a realistic estimate for carbon and stock changes in the national estate for the period under consideration.

Although the total carbon stock in the national estate is increasing and the trend of net storage is also upwards, this pattern is uneven. This probably reflects changes n annual planting programmes and their movement from unclassified to young forest in the model. It may also be noted that clearfelling reached a high level in 1999, which also coincides with a dip in the increase in net annual storage from 0.28 to 0.21 M t C. Felling was lower in 2000 which resulted in an increase in net carbon storage.

Forest soils

Measuring and predicting changes in soil carbon stocks is extremely difficult. This is mainly due to high spatial variability and the fact that changes are usually very small relative to the total carbon stock. Carbon stored in forest soils is estimated to be a very significant component of the forest ecosystem storage (Byrne 2001). An estimate of the average carbon store in forest soils is 305 t C ha^{-1} (COFORD 2001). Taking this into account suggests that the total carbon stock in the national estate may been 112 M t in 1990 and increased to 137 M t in 2000 (areas under forest cover only).

Using the model

The model presented here represents an interim step in the development of a forest carbon accounting system. It has a degree of flexibility and can be adapted as new information becomes available. Changes can be made to all conversion factors relating to a stocking, species volume per ha, planting and clearfelling and factors used to convert commercial wood biomass to carbon.

The assumption made that young crops reflect conditions from age 7 onwards may not represent conditions on the ground in 1995 and underestimate carbon stock if crops were older so options for ages up to 10 years and over can be chosen. Assumptions made with regard to volumes and forest biomass are conservative.

The model can be extended from 2000 on, distinguishing between all forests and those planted from 1990 onwards, using either actual planting rates or assumptions to evaluate the impact of various planting and felling policies on future carbon storage. For example, an adjustment of predicted clearfelling levels can indicate the threshold which would result in no net carbon storage in older forests.

Improving the model

Accurate, up-to-date information is essential for realistic carbon stock estimates and predictions, so the completion of a full national inventory is a highly important part of the reporting process. When this inventory is completed the model can be revised by including up-to-date planting and felling data, age and species distributions, volumes, increments and stocking levels.

In the model, crops under 7 years of age were considered to have no net carbon sequestration below this age. The results of the COFORD-funded CARBIFOR project will help to clarify the situation as far as those crops are concerned.

A large area of FIPS was classified as cleared. This includes actual clearfelled areas, newly planted areas or otherwise unidentified areas. The provision of afforestation and reforestation dates through the Forest Service planting grant system, across the species categories defined by FIPS would provide more complete information on very young crops and their progress over time to the other crop development categories.

The work has also highlighted the need for more information on both thinnings and clearfelling by species in the private sector. Information on areas clearfelled would be particularly useful in using the model for future prediction. This could be recorded through the Forest Service felling licence system.

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Appendix 1

Operation of the model to determine forest areas in the FIPS categories forwards and backwards from 1995

The changes in forest classification over time shown in Figure 1, Appendix 1 below.

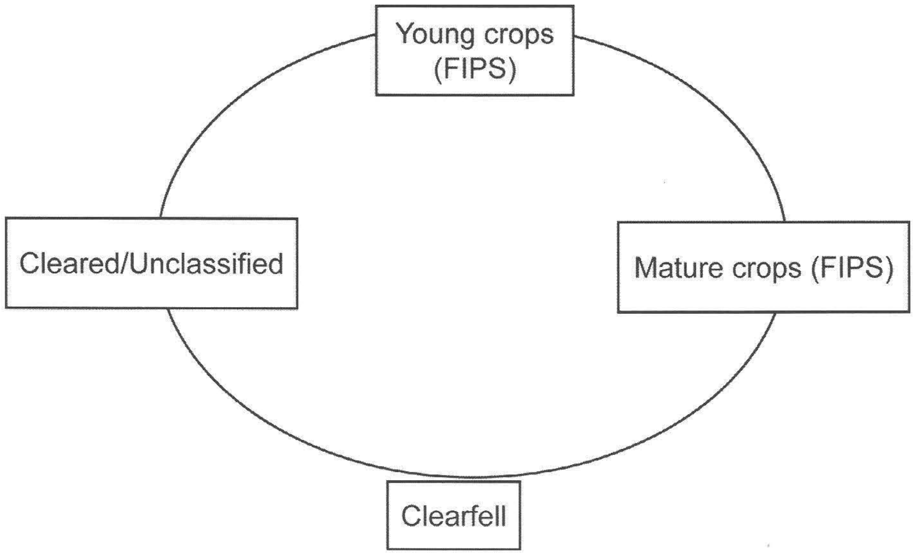

Figure 1, Appendix 1. *The harvest/regeneration cycle and associated changes in forest classification.*

The assumptions used to assign to the three different categories were:

1. Afforested and reforested areas 7 years and over, defined as cleared/unclassified in FIPS move each year into the young crops category. Areas were derived from Coillte felling and Forest Service planting records.
2. 5.6 percent of the young crop category moves each year into the mature category (at 25 years). This means that there is a full turnover of these crops every 18 years.
3. Mature crops are clearfelled and these areas come back to the cleared/unclassified category.
4. For the purposed of the model clearfell is defined as Coillte felling plus a representative 200 ha of private felling.
5. Clearfell is presumed to equal the following year's reforestation
6. The process works forwards or backwards from FIPS base year 1995.

Examples

Young crops

1995 ha = FIPS ha for 1995 for a given category

1996 ha = (1995 ha + (afforestation 1989 + reforestation 1989) x species %) – 1995 ha x 0.056

1997 ha = 1996 ha + (afforestation 1990 + …

1994 ha = 1995 ha – (afforestation 1988 + reforestation 1988) x species % + 1995 ha x 0.056

1993 ha = 1994 ha – (afforestation 1987 + …

Mature crops

1995 ha = FIPS ha for 1995 for a given category

1996 ha = 1995 ha + (1995 young ha x 0.056) – clearfell 1996

1997 ha = 1996 ha + (1996 young ha x …

1994 ha = 1995 ha – (1995 young ha x 0.056) – clearfell

1993 ha = 1994 ha – (1994 young ha x …

Appendix 2

Carbon stocks, annual net carbon increment and harvest from forests in the Republic of Ireland for 2000 using a modified Table 5a (common reporting format approach).

Table 1, Appendix 2. *Carbon stocks, harvest and increment in Irish forests for the year 2000 according to United Nations Framework Convention on Climate Change, Common Reporting Format, Table 5a format.*

		Area	*Stemwood Overbark*	*BEF*	*Basic density*	*Total tree biomass*	*Carbon content*	*Carbon*	*Total carbon*
		ha	*m^3*	*$t\ t^{-1}$*	*$t\ m^{-3}$*	*$t\ dm\ ha^{-1}$*	*$t\ t^{-1}$*	*$t\ C\ ha^{-1}$*	*t*
Plantation	*Quercus*	5921	207.73	1.6405	0.55	187.43	0.5	93.72	554919
	Fagus	3336	204.22	1.6405	0.55	184.26	0.5	91.13	307364
	Other BL	51885	118.56	1.6405	0.55	106.98	0.5	53.49	2775260
	BL Total	61142							
	Pinus	93539	96.93	1.6405	0.40	63.60	0.5	31.8	2974740
	Picea	247048	125.49	1.6405	0.35	72.05	0.5	36.03	8900277
	Other CF	24141	121.88	1.6405	0.41	81.98	0.5	40.99	989583
	CF Total	364728							
	Mixed	30914	127.76	1.6405	0.48	100.61	0.5	50.30	1555057
	Other	1900	127.20	1.6405	0.55	115.04	0.5	57.52	109289
	PLT Total	458884							

Total Growing Stock 2000 (Gg C)	18145492
(Gg CO_2)	66533471
Total Growing Stock 1999 (Gg C)	17885113
(Gg CO_2)	65578746
Annual Increment after Harvest 1999 – 2000 (Gg C)	260379
(Gg CO_2)	954724

	Stemwood overbark	*BEF*	*Basic Density*	*Total DM*	*Carbon content*	*Carbon release*
	m^3	*$t\ t^{-1}$*	*$t\ m^{-3}$*	*t*	*$t\ t^{-1}$*	*t*
Biomass Removed in Commercial Forest	3008451	1.6405	0.3702	1826877	0.5	913448
Traditional Fuelwood Consumed						
Total Other Wood Use						
Total Biomass Consumption from Stocks					*(Gg C)*	913448
					(Gg CO_2)	3349312
Net Annual Carbon Uptake/Release (+/-) (Gg C)						
Net CO_2 emissions/removals (+/-)(Gg CO_2)						