Comparative Irish and American Hardwood Culture

*I. One Tree to the Acre: The Value and Silviculture of Fine Hardwood Management on Small Woodlots in the Midwestern U.S.**

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Summary

Because the midwestern US and Ireland share similar agricultural landscapes, information on hardwood culture and reforestation efforts is presented for comparison. Historically, the respective land areas were once heavily forested, but land clearing for agriculture in both countries has resulted in relatively small, fragmented woodlots. This makes farm-forestry an important component of forest production in these landscapes. The status of Indiana hardwood forest is provided with current growth and species trends. Timber values and recent timber sales figures by species are included for contrast with Irish woodlots and the long-term trends of sawlog prices in Indiana are provided which show the competitive rates of return that hardwood management can bring.

Introduction

Much of the midwestern U.S. shares a common ecological landscape with rural areas of Ireland. Broad-leaved forest, once covering most of Ireland and the eastern U.S., has been dramatically reduced by human activity i.e., conversion to agriculture (Watts 1985, Edwards 1985, Noss 1987). Thus, the resulting landscapes are a patchwork of relatively small woodlots in an agricultural matrix (Figure 1). This similar heritage has led to parallel ecological and economic problems. Economically, the focus on agriculture in both countries has led to a general decline in the quality of the woodlands. Silvicultural practices have been neglected, with high quality stems usually selectively removed to provide short-term income to farmland owners. Characteristic of Irish woodlands (Cross 1987), this is also reflected in the scarcity of management on private lands in the eastern U.S. (Nyland 1992). In Indiana, for example, only 20% of timber sales are conducted with the aid of a forester. Additional problems include overgrazing in woodlots (causing defect and rot in existing trees as well as loss of regeneration), a

Figure 1. Typical northern Indiana landscape of small forest properties enclosed in an agricultural matrix, often connected by hedgerows.

decline in the available hardwood resource for industry, and the reliance of a large segment of the population on agricultural commodity production.

Ecologically, forest fragmentation is recognized in both countries as contributing to the decline or extinction of wildlife and plant species; species associated with the interiors of undisturbed forests and important for maintaining biodiversity (Jeffrey 1984 in Cross 1987, Noss 1983). The establishment and conservation of the broad-leaved forest resource in both countries is demanding alternative (and creative) silvicultural practice including a shift away from clearcutting, use of new tools such as tree shelters, establishment of a distribution of age classes, increasing rotation length for some species to increase tree size, and production (either naturally or artificially) of standing snags and dead and down timber for wildlife use (Neff 1974 in Cross 1987, Parker 1989).

Involvement by farmland owners and the introduction of grant schemes for planting and stand management are assisting in the effort to maintain quality hardwoods in both countries.

Historical Forest Cover

The historical midwestern U.S. landscape, and specifically that of the state of Indiana, can be pieced together from travel accounts of pioneers and surveyors (McCord 1970) as well as historical legal documents. Pollen records also present the earlier dynamics of forest species migration into the area during post-glacial development (Delcourt and Delcourt 1987). At the time of intensive settlement in the late 1700's to early 1800's, a forested landscape dominated by mesic forest species was found (87% of the 9.2 million hectare land area of Indiana) with the balance in prairie and wetlands to the north. Heavy clearing of forests for farming occurred during the mid 1800's in Indiana and today only 19% of the land area remains under forest cover. In comparison, Ireland's forests once covered nearly all of the island, reaching their maximum around 5000 B.C. (Cross 1987). Clearing of forest began much earlier in Ireland of course, and by the Middle Ages, Ireland had acquired much of its present landscape, with only 1% of the land under native hardwood forest today.

With such major clearing of forest land, associated animal species have undoubtedly been impacted in both countries. In Indiana, forest clearing has been associated with the loss of buffalo, wolves, black bear, and various other mammal and bird species from the state.

The Forest Resource Today

Today's midwestern U.S. forest is dominated not by the mesic, late-seral species of the past, such as sugar maple (*Acer saccharum* Marsh.) and American beech (*Fagus grandifolia* Ehrh.), but by more xeric species, the red and white oaks (*Quercus* spp.) and hickories (*Carya* spp.). The dominance of oak, however, is transient, due to the abuse of the forest during settlement. The use of fire by Native Americans was adopted by the large numbers of Europeans settling in Indiana and it was common for large fires to be burning across the state in the 1800's. In addition, the Europeans brought livestock that were left to graze in the forests, impacting regeneration. These heavy disturbances arrested succession, maintaining mid-tolerant species. Thus, with settlement came a shift in forest species, from late-seral, very shade-tolerant species to the mid-tolerant oaks and hickories whose ability to quickly resprout after disturbance allowed eventual dominance in the forests of the state and region. With the removal of fire and woodland grazing from the landscape since the early 1900's, Indiana's forests are returning to their original composition, where oaks are mixed with 20 to 30 species of other hardwoods (Table 1). Irish forests seem to be similar in that the large oak component found today is a function of management during the 18th and 19th centuries. Previously, as in the U.S., oak would have been found in association with other tree species according to site (Cross 1987, Mitchell 1976, Edwards 1985).

Table 1. Stand tables presenting numbers of trees per hectare by species and tree size for two Indiana woodlands on moist and dry sites.

A. Southeast Purdue Agriculture Center Woodlands – Mesic Site, Two-Aged Stand 50-110 Years, Good Productivity.

	Diameter Classes (cm)													
Species	5	10	15	20	25	30	35	40	45	50	55	60	65	
REM	12	12	5	13	9	8	9	16	7	3	1	1		96
SHH	4	13	17	16	15	1	11	3	1					81
SWG		1	17	13	11	4	11	1	3	3				64
SAS			3	4	5	5	5	3		1	1			27
BLG	13	24	7	3			1	3	5		3			59
SWO				3	7	5	5	3			1			24
YEP						1		1	1		1		3	7
WHA		1		3	9	5	4	3						25
NRO		1	1	1		1			1		1			6
WHO					3		1	1	1					6
BIH				1	1		1	3						6
REE	5	5	5	1	1						1			18
BLC	5				1			1						7
PIO								1						1
DOG	21	5												26
AMB	36	1												37
HOR	12	1												13
Totals	108	64	55	58	62	30	48	39	19	7	9	1	3	503

B. Clark State Forest – Xeric Site, 70-90 Years, Poor Productivity.

Diameter Classes (cm)

Species	5	10	15	20	25	30	35	40	45	50	55	60	65	
WHO	5	12	9	17	23	44	44	27	8	8	1			198
BLO	4				3	4	1	4	4	1	1	1		23
PNH	3	11	8	9	5	1	1							38
SCO								1						1
DOG	44	8												52
SHH	12	12	1	1										26
REM	8	9	1	1										19
WHP	11	8												19
SUM	1	5	1	1										8
VIP					1									1
REC	4	3												7
BLG	1	3												4
SAS	1	1												2
WHA			1											1
REE	3													3
RED		1												1
BLC	1													1
Totals	98	73	21	28	33	49	46	32	12	9	2	1		404

Species Key

Code	**Common Name**	**Scientific Name**
AMB	American Beech	*Fagus grandifolia* Ehrh.
BIH	Bitternut Hickory	*Carya cordiformis* (Wangenh.) K. Koch
BLC	Black Cherry	*Prunus serotina* Ehrh.
BLG	Black Gum	*Nyssa sylvatica* Marsh.
BLO	Black Oak	*Quercus velutina* Lam.
DOG	Dogwood	*Cornus florida* L.*
HOR	Hornbeam	*Carpinus caroliniana* Walt.*
NRO	Northern Red Oak	*Quercus rubra* L.
PIO	Pin Oak	*Quercus palustris* Muenchh.
PNH	Pignut Hickory	*Carya glabra* (Mill.) Sweet

REC	Redcedar	*Juniperus virginiana* L.
RED	Redbud	*Cercis canadensis* L.*
REE	Red Elm	*Ulmus rubra* Muhl.
REM	Red Maple	*Acer rubrum* L.
SAS	Sassafras	*Sassafras albidum* (Nutt.) Nees
SCO	Scarlet Oak	*Quercus coccinea* Muenchh.
SHH	Shagbark Hickory	*Carya ovata* (Mill.) K. Koch
SUM	Sugar Maple	*Acer saccharum* Marsh.
SWG	Sweetgum	*Liquidambar styraciflua* L.
SWO	Swamp Chestnut Oak	*Quercus michauxii* Nutt.
VIP	Virginia Pine	*Pinus virginiana* Mill.
WHA	White Ash	*Fraxinus americana* L.
WHO	White Oak	*Quercus alba* L.
WHP	White Pine	*Pinus strobus* L.
YEP	Yellow Poplar	*Liriodendron tulipifera* L.

*Understory tree only

In Indiana, species dynamics are creating several problems. The reliance on oak by forest industry is mandating a shift in species used in furniture, paneling, and other segments of the industry as quality oak logs become more scarce. For over a century, U.S. foresters have recognized the difficulty in regenerating oak as natural succession without severe disturbance replaces oak with the late-seral maple and beech. Today, the oak-hickory cover type accounts for only 33% of Indiana timberland, down from 61% in 1966 (Smith and Golitz 1988). Thus, millions of dollars have been funneled to research oak regeneration systems. Similar efforts for growing oak and other fine hardwoods are developing in Ireland (e.g., Fitzsimons and Luddy 1986, Neilan 1992, Markey 1992) though land availability and longer rotations are problems to overcome. Our biological understanding is improving (Gillespie 1992), but social constraints are requiring a diversification of production systems. In the U.S., aesthetic and environmental concerns in the Midwest continue to increasingly limit silvicultural practices suited to oak regeneration and harvesting. As a result, oak management is being shifted from public lands to woodlands of private ownership, woodlands in the agricultural matrix. Similarly, economic and social dynamics in Ireland are opportune for promoting diversification of traditional farming (with surplus supply) into forestry as well as diversifying state forestry plantings to include hardwoods to a greater extent.

Indiana's forest resource today covers a wide range of sites and productivity classes, just as for Ireland. The standing growing stock volume (trees greater than 13 cm to a 10 cm top) averages 85 cubic meters per hectare. Standing sawtimber volume (trees greater than 30 cm to a 23 cm top) averages 11,043 board feet per hectare or 62.5 m^3/ha.[1] Net annual growth of growing stock averages 2.5 m^3/ha/yr, quite low. Actually, potential growth is at least two to three times higher (5-7 m^3/ha/yr) but many of Indiana's forests are overmature and/or have been degraded by selective cutting. Net annual growth of sawtimber (>30 cm) averages 418 board feet per hectare per year or 2.4 m^3/ha/yr, nearly three times the rate in 1966. Biomass averages 171 green Mg/ha (Smith and Golitz 1988). Examination of species distributions shows the trend of increasing growing stock, but also the decline in oak dominance as maple, yellow poplar (*Liriodendron tulipifera* L.), and white ash (*Fraxinus americana* L.) increase in numbers (Figure 2). Size class distributions also show the maturity of Indiana's hardwoods with relatively small areas of semi-mature and regeneration size classes (Figure 3).

The majority of the forestland in Indiana is structually even-aged and in the past even-aged techniques were used for regeneration. As most Indiana forest land is in private hands (1.5 million hectares of 1.8 million or 83%), future management will most likely convert these stands to uneven-aged stands where the conversion to sugar maple will be accelerated (Gillespie *et al.* 1993). Private ownership probably also accounts for the over-maturity of the forest, and lack of younger stands.

Value of the Hardwood Resource

Recently, a question was posed for Irish Forestry, "The question is can we afford to invest in hardwood production, will there be a return on any investment made?" (Gallagher 1987). In the U.S., the Central Hardwood region contains some of the most valuable timber in the world, and the best quality oak and black walnut (*Juglans nigra* L.) logs in Indiana are often shipped to European markets. Analysis of some recent Purdue University timber sales shows excellent returns (Tables 2 and 3). In the Nelson-Stokes woodlot, approximately 25 trees per hectare were harvested in 1992 (Table 2), giving an average value of roughly £170[2] per tree. This is well within the potential of Indiana hardwoods stands, however, this potential is not often realized due to repeated selective cutting.

[1] Board foot measure is the preferred sawtimber measure in much of the U.S. Unfortunately, conversions are species and size specific, and there are a number of board foot rules. All board foot measures reported here are International 1/4-inch rule and 5 board feet per cubic foot is used as the conversion to cubic meters. This conversion is taken from the USDA Forest Service Resource Bulletin NC-108, Indiana Forest Statistics. Cubic foot – board foot conversion rates for 9" to 29" trees (22.8 - 73.7 cm) range from 4.8778 to 5.2718 for hardwood trees (International 1/4-inch), thus 5 board feet per cubic foot was chosen for convenience.

[2] The exchange rate used in all calculations is \$1.50 = IR£1.

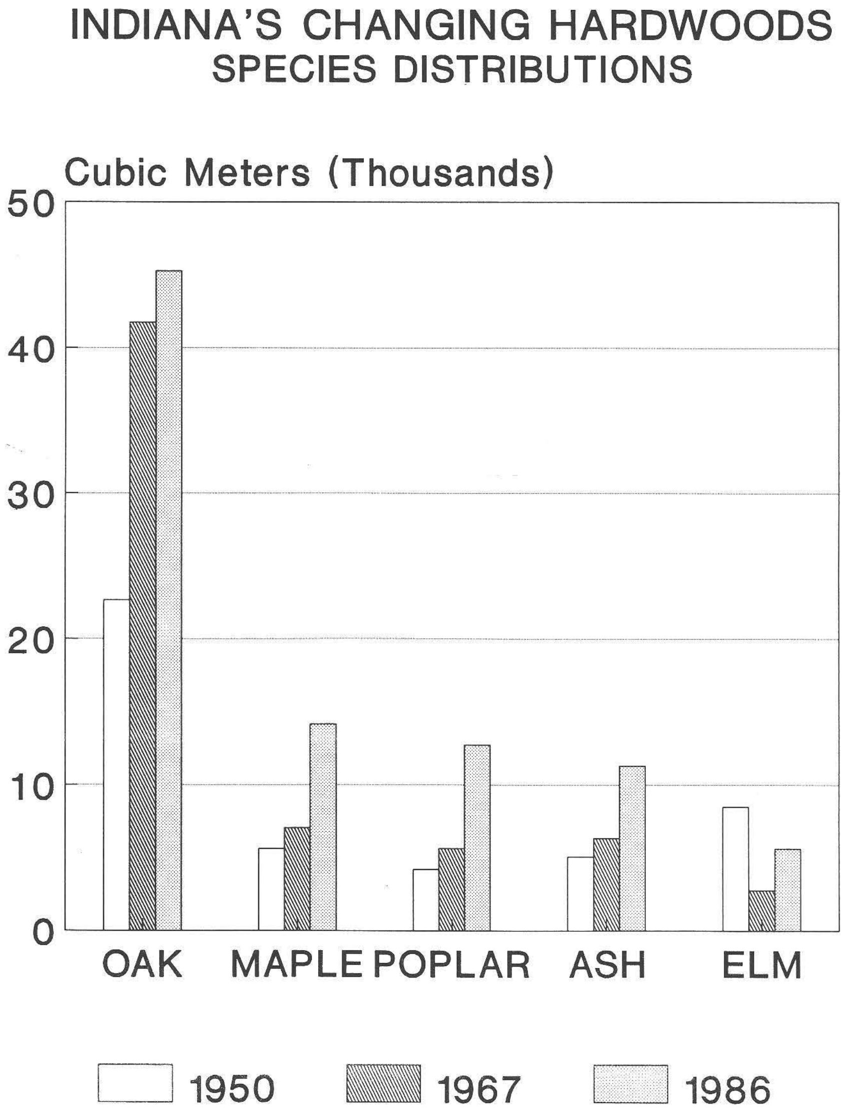

Figure 2. Species dynamics in Indiana forests over time. (Adapted from Smith and Golitz, 1988).

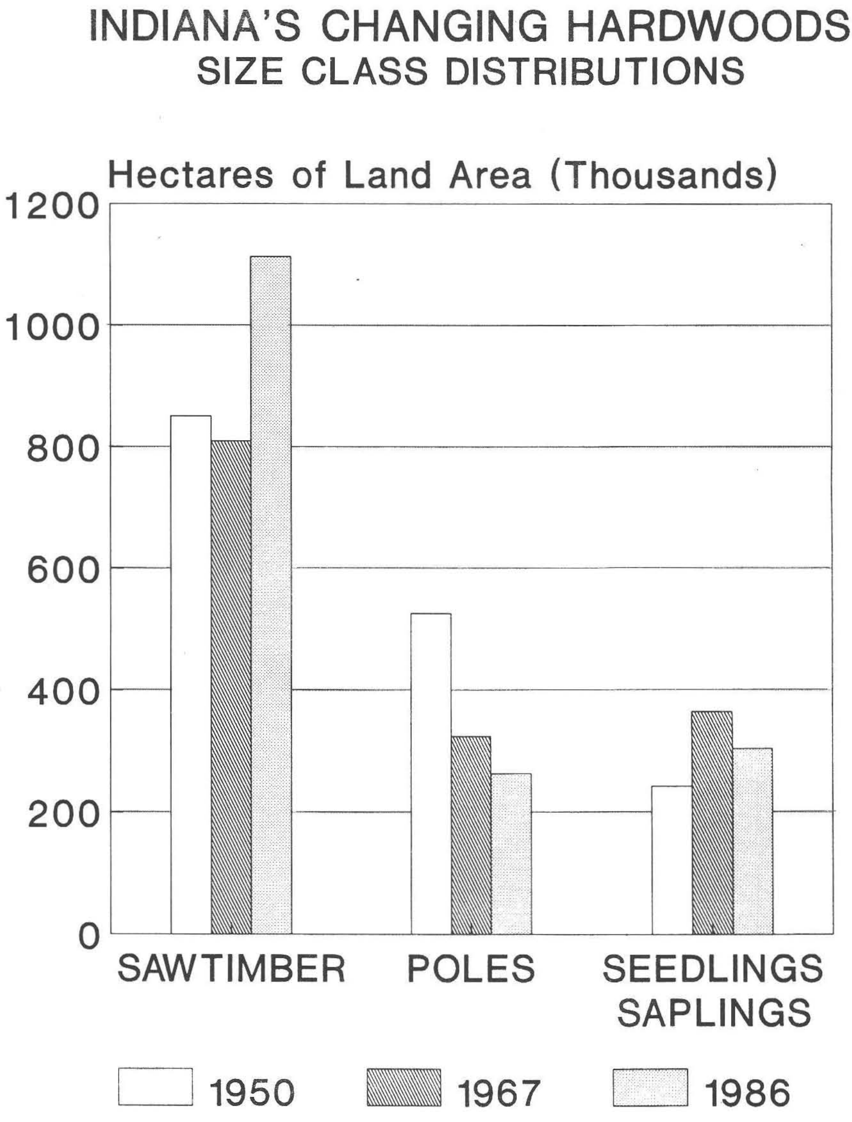

Figure 3. Size class distributions for Indiana forests over time. (Adapted from Smith and Golitz, 1988).

This particular stand will provide 1-2 more harvests (thinnings) before being regenerated. The 8% real rate of return places management of this stand well in excess of many alternative investments, even with the purchase of land and timber in 1960. It should be noted that some costs have not been figured into this simplified analysis. Annual property taxes would be an additional cost, but because of Indiana tax incentives for forestland, this cost becomes minimal. Also, administrative management costs (e.g. management plans, soils maps, etc.) are not included as these functions are normally provided to landowners by government foresters (at the State level). What costs there are for mature stand management (e.g. fence maintenance, timber sale marking) are either cost shared by government grant schemes or taken out of sale proceeds. Sometimes, however, the State District Forester will also mark timber sales. Thus, the information and extension component for forestry seems much stronger within the U.S. government (Federal and State) than within the Irish government. Finally, sale proceeds would be subject to the U.S. income tax structure.

Table 2. Cash flows and rates of return for a recently-harvested central Indiana hardwood stand. Adapted from Mills (1993).

Nelson-Stokes Woods, Compartment 2
36.2 hectares

			Volume per Hectare	
Year	Activity	Bd. Ft. Cash Flow (IR£/ha)	Cubic (Int. 1/4″)	Meters
1960	Purchase			
	Land	–50		
	Timber	–200	11,935	68
1977	Salvage	8	205	1
1992	Harvest	4,280	10,667	60
	Residual Stand	5,617	21,142	120
	Land Value	412		

Range of Bids: IR£85,926 – 154,667

Rate of Return = 12 – 12.5%
(8% after inflation)

In a second Purdue University timber sale, a much higher rate of return (20%) was earned, again including purchase of land and timber (Table 4). This was an exceptional stand with large trees of high quality. Examples such as this are becoming more scarce, and tree dimension requirements have

Table 3. Timber sale tally for Nelson-Stokes woodland, 36.2 hectares.

Species	Number Of Trees	Estimated Volume Board Feet (Int. 1/4″ Rule)	Estimated Volume Cubic Meters
Red Oak (*Quercus rubra* L.)	206	108,541	615
White Oak (*Quercus alba* L.)	228 (47 veneer)	81,895	464
Hickory (*Carya ovata* (Mill.) K. Koch)	227	68,885	390
Basswood (*Tilia americana* L.)	21	6,918	39
Sycamore (*Platanus occidentalis* L.)	8	6,285	36
Sugar Maple (*Acer saccharum* Marsh.)	20	4,689	27
White Ash (*Fraxinus americana* L.)	69	36,206	205
Chinqapin Oak (*Quercus muehlenbergii* Engelm.)	26 (3 veneer)	8,898	50
American Beech (*Fagus grandifolia* Ehrh.)	35	8,306	47
Red Elm (*Ulmus rubra* Muhl.)	38	14,800	84
Yellow Poplar (*Liriodendron tulipifera* L.)	10	7,527	43
Black Walnut (*Juglans nigra* L.)	55 (21 veneer)	15,446	87
Black Cherry (*Prunus serotina* Ehrh.)	4	2,033	12
Blue Ash (*Fraxinus quadrangulata* Michx.)	2	1,143	6
Sassafras (*Sassafras albidum* (Nutt.) Nees)	24	6,646	38
Hackberry (*Celtis occidentalis* L.)	3	1,966	11
Misc.*	6	1,285	7
TOTAL	982	381,469	2,161

*Includes honey locust (*Gleditsia triacanthos* L.), red maple (*Acer rubrum* L.), and Kentucky coffeetree (*Gymnocladus dioicus* (L.) K. Koch) been greatly reduced. Thus, much smaller logs are now being harvested and trees are grown to smaller sizes.

Table 4. Cash flows and rates of return for a recently-harvested southern Indiana hardwood stand. Adapted from Mills (1993).

Cupps Chapel Woods
15.4 hectares

			Volume per Hectare	
Year	Activity	Cash Flow (IR£/ha)	Bd. Ft. (Int. 1/4″)	Cubic Meters
1973	Purchase (Land and Timber)	–659	22,306	126
1977	Harvest	1,352	3,403	19
1982	Road Repair	–15		
1992	Harvest	4,509	14,401	82
	Residual Stand	3,929	18,073	102
	Land Value	412		

Range of Bids: IR£38,631 – 69,333

Rate of Return = 25%
(20% after inflation)

These stands are examples of existing stands that were purchased and managed. Returns from these properties are inflated due to increasing land values as competition for alternate land uses increased. But this would be true whether the crop was trees, corn, or hay. The value of the mature timber, however, demonstrates the benefit of purchasing timber in mid-rotation where quality stands can be found. Alternatively, the purchase of undervalued land can also lead to large returns. Examples of this strategy can be found in the U.S. where bottomlands that periodically flood are sold at a low price by farmers. Foresters purchase such lands and plant high-value bottomland species (e.g. black walnuts, wet-site oaks) which exhibit very high growth rates on these sites where crops or pasture would be destroyed. Beyond land speculation, timber management of existing stands provides competitive returns where individual hardwood growth is accelerated through thinning operations. Increases in size, value, and product grade with management are the real factors contributing to the profitability of existing stand management. Many future stands are only now being established, either by farmers or other landowners. The returns made from these stands are also favorable. During a recent Society of American

Foresters (Indiana Chapter) workshop, private consulting, state, federal, and university foresters put together an example of the costs and return from an 80-year rotation, mixed-hardwood plantation (Table 5). Assuming in this instance that the land was already owned, the landowner could expect a real return of 4 – 4.5% (all monetary values in this analysis are uninflated). Thus, with purchase of nursery seedlings, site preparation and planting, weed control for three years (herbicide), and pruning and precommercial thinning, a competitive rate of return can be earned by the landowner. This is without any government grant schemes or premiums. Where these programs are used by landowners, particularly farmers taking marginal land out of crop production, the return would be substantially higher.

Table 5. Cash flows and return from a hardwood plantation in Indiana given 1993 prices and returns.

Hypothetical Mixed Hardwood Plantation

Year	Activity	Cash Flow (IR£/ha)	# of Trees/ha
0	Plant/Weed	–494	1,680 @ 2.5m
1	Weed Control	–66	
2	Weed Control	–66	
8	Prune	–99	
18	PreComm Thin	–82	740
25	Thin	25	494
40	Harvest	165	247
60	Harvest	4,118	124
80	Harvest	8,237	0

Rate of Return = 4 – 4.5%

The real value, however, comes from black walnut trees. Because of the price commanded by walnut, foresters often manage walnuts individually, and it is the first species distinguished in any inventory process. The record price for a single black walnut tree (from Ohio) was £23,333. Today's prices would be higher. Foresters also recognize that a single, high-quality walnut tree on an acre can pay for the management of the associated timber – thus the title of this paper. On a volume basis, walnut prices are 20-40 times those of other quality hardwoods, and it is the species of choice for plantations throughout the Midwest. Most of the effort of genetic improvement in the Midwest has been spent on walnut and growth rates for improved stock compare very favorably with other important forest species (Table 6). Presumably, these rates would be matched or exceeded for these same species growing in Ireland for the reasons outlined below. The Indiana hardwood industry has used 30 cm logs for walnut veneer though it prefers a 40+ cm log. Given the growth rates for improved walnut, these diameters could easily be reached in 35-40 years. At the Purdue experimental forest, one such walnut clone is 36 cm DBH at 22 years of age (Beineke, pers. comm.). Walnut rotations can be realistically set at 45-55 years, but the rate of increase in value at this size argues for longer rotations. Clearly, owner objectives and cash flow needs would dictate rotation length beyond 40 years. Irish analyses typically use a 60 year rotation for ash (*Fraxinus excelsior* L.) and sycamore (*Acer pseudoplatanus* L.) (Neilan 1992, Fitzsimons 1987). With improved seed sources or substitute species of equal or greater value (such as black walnut), financial comparisons would be more favourable due to both value and shorter rotations.

Table 6. Comparative diameter growth rates of major hardwood species in Indiana.

Species	Diameter Increase Per Year
White Oak (*Quercus alba* L.)	0.46-0.51 cm
Red Oak (*Quercus rubra* L.)	0.51-0.76 cm
Hickory (*Carya ovata* (Mill.) K. Koch)	0.25 cm
Sugar Maple (*Acer saccharum* Marsh.)	0.50 cm
Beech (*Fagus grandifolia* Ehrh.)	0.25-0.50 cm
Improved Black Walnut (*Juglans nigra* L.)	1.27-1.95 cm

Irish Conditions

In addition to the value of hardwoods, several other factors should be considered by Irish foresters when planning investments. First, the climate in Ireland is such that abundant rainfall and moderate annual temperatures make Ireland an ideal location for growth of most hardwood species. This is due to the lack of hot, dry periods when water deficits slow tree growth. In addition, with cooler and wetter conditions, trees allocate less carbon to roots and more to stems as well as requiring less carbon for maintenance respiration, i.e., more stays in the tree. This sort of climatic synergism can be seen for other species that have been imported to new locations, for example loblolly pine (*Pinus taeda* L.) which supports the paper industry in southern Brazil (Gillespie, unpublished data). This argument must be qualified where

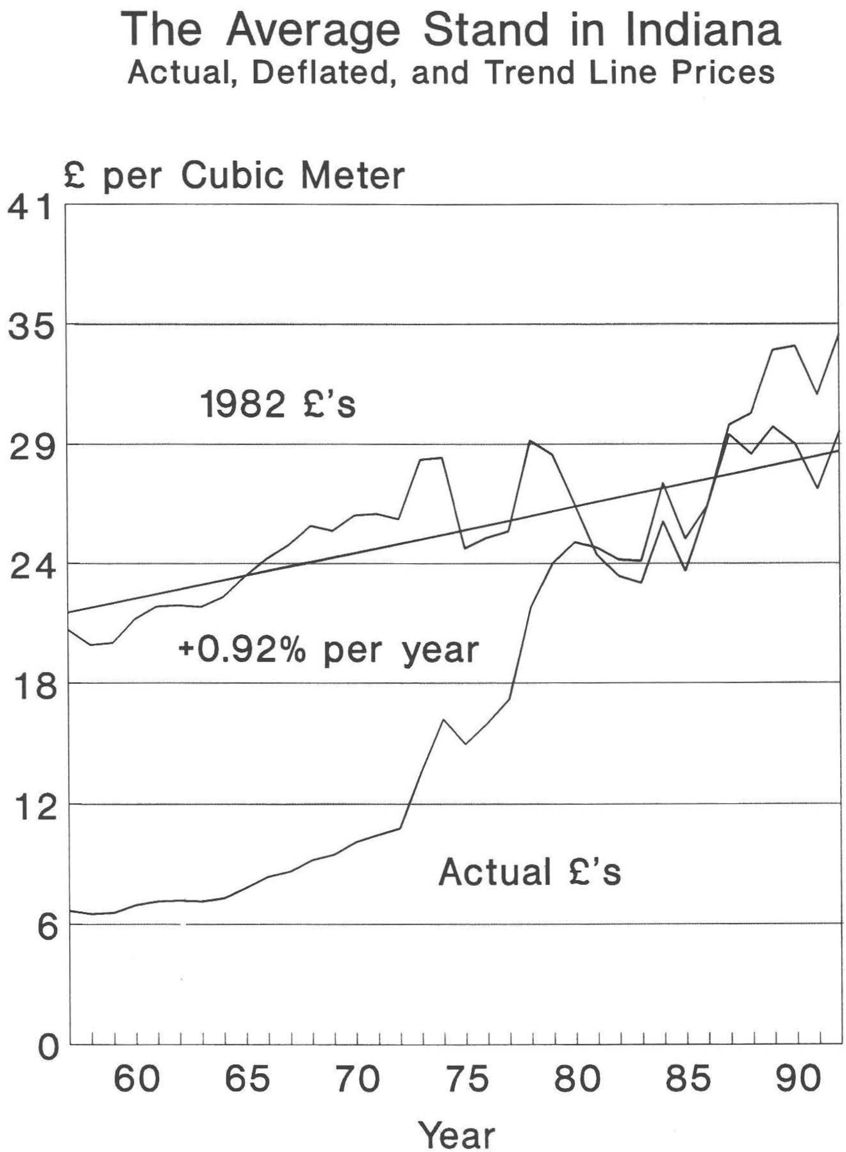

Figure 4. Prices for sawlogs (25+ cm DBH) from a hypothetical stand in Indiana comprised of an "average" or typical mix of species and sizes. The defined stand remains unchanged for all years of analysis and adjustment to 1982 is in dollars; conversion assumes a constant dollar:pound exchange rate of \$1.5 = IR£1. (Adapted from Hoover *et al.*, 1992).

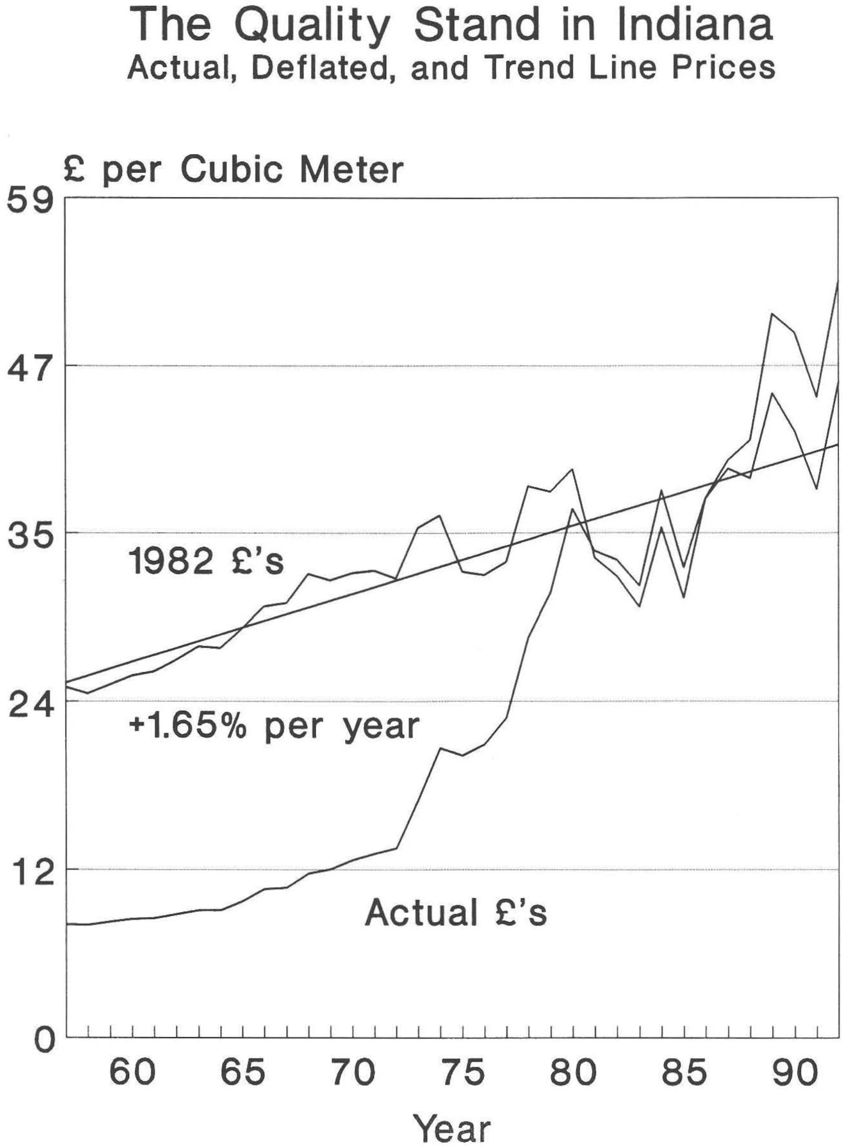

Figure 5. Prices for sawlogs (25+ cm DBH) from a hypothetical stand in Indiana comprised of a better-than-average mix of valuable species and sizes. The defined stand remains unchanged for all years of analysis and adjustment to 1982 is in dollars; conversion assumes a constant dollar:pound exchange rate of \$1.5 = IR£1. (Adapted from Hoover *et al.*, 1992).

restricted annual growth improves product quality in current markets (e.g. veneer oak).

Secondly, Ireland imports both temperate and tropical hardwoods for indigenous industries. As environmental pressures continue to grow, and as sources become depleted, inaccessible, and of lesser quality, importation will be less cost effective. At this point, native sources will be much more attractive financially and socially. But thinking should not be restricted to supplying Irish industries, though this is currently the necessity. Hardwood exports to the EC might be much more attractive financially where markets differ from internal Irish markets. As stated previously, Indiana hardwoods are regularly exported to many different countries in the EC and the requirements (in terms of raw material dimensions and grain patterns, etc.) are often mutually exclusive due to different consumer preferences. Thus, not all investment decisions can be made using internal conditions and rates of return, particularly with regard to hardwoods.

In Summary

The opportunity cost of minimal hardwood management for the U.S. and Irish governments is appreciable, and the private sector in each country is taking the lead in planting and management. With good cooperation, this should not pose a problem. Long-term data support the private sector initiatives (Figures 4 and 5). Increases in hardwood prices above inflation are 1-2% each year (Hoover *et al.* 1992). Coupled with volume growth of 2-3% annually, returns are 4-5% for hardwood timber, easily competitive with many investment alternatives. Additionally, increases in quality and log grade with tree growth provides an additional return of 2-3%. Thus, hardwood production is clearly an attractive investment, and demand continues to grow. Social and environmental constraints are the real challenges for foresters in both the U.S. and Ireland as we move into the next century.

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