VALUE OF THE MORGAN-MONROE-YELLOWWOOD STATE FOREST COMPLEX

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Abstract.—As publicly owned forest land, the Morgan-Monroe and Yellowwood State Forests (Indiana), referred to herein as the Morgan-Monroe Yellowwood Complex (MMYC), have many stakeholders with differing management expectations. The Hardwood Ecosystem Experiment (HEE) within the MMYC will significantly increase the science-based information available for forest management decisions. The primary focus of HEE is the impacts of alternative timber management systems on associated communities of flora and fauna. The results will be used to evaluate tradeoffs associated with mixes of silvicultural treatments. Rogers et al. (this publication) found that the values recreationists and adjacent landowners associate with forest scenes declined with decreasing stand density. The range of values ascribed to forests is discussed in this paper to provide a broader context for interpretation and application of HEE findings. Particular emphasis is given to monetized institutional values using discounted cash flow analyses of silvicultural treatments. The results indicate that land expectation values are lower for silvicultural treatments with lower stand densities because of higher opportunity costs from pushing timber revenues into the future. The implications of these findings were found to differ depending on management objectives and the scale at which decisions are made.

INTRODUCTION

Wood was the foundation of the North American economy from earliest European settlement until the coal age (Perlin 1989). Forests are still synonymous with wood products and value-added activities for many stakeholders. Although wood remains a vital commodity, the return of fully stocked forests has provided opportunities for viewing them in a broader context. In many areas public forests offer the only accessible and relatively large contiguous blocks needed for aesthetic value. Forests give some individuals a mystical feeling, especially when in the presence of large trees. Others sense they are a creature of the forest, their true ancestral home. Others feel lost and out of place in a forest. Some forests are cultivated like crops, *Fructus industriales*; others are *Fructus naturales*, resulting in varying perceptions of human intervention in the dynamics of forests. Policy makers and forest managers are challenged to choose options that account for this wide range of attitudes, especially considering the short-term impacts of some silvicultural techniques. Many forest benefits are complementary; others are mutually exclusive, depending on desired outcomes and the timeframe used for evaluation of alternatives.

Many stakeholders' expectations are based on values not rooted in forest science and the tradeoffs estimated for the full range of benefits. Results from the Hardwood Ecosystem Experiment (HEE) in Indiana will be more useful if they are framed within the broad range of values stakeholders will bring to the interpretation of findings and implications drawn.

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After setting the Morgan-Monroe-Yellowwood Complex (MMYC) in its physical and institutional contexts, I review the types of values and discuss their applications to forests. The fiscal management of the MMYC is not discussed because of its political context. Specifically, the 100-year horizon of the HEE makes it necessary to avoid to the extent possible the vagaries of cyclic changes in political climate. For similar reasons I do not discuss opportunities to generate revenue streams from non-timber forest uses, or the efficiency and efficacy of current administrative and operational management practices.

Given the HEE's focus on alternative silvicultural techniques, it was important to value socio-economic tradeoffs among them. Monetized instrumental value, i.e., market value, of revenue and cost streams was used. Standard discounted cash flow techniques were applied. Land expectation values (LEV) were estimated for a range of assumptions for three silvicultural techniques and for the MMYC as a whole using the current allowable cut. Future analyses should consider the relationship between the mix of silvicultural treatments applied across the entire forest and allowable cut.

Data for monetization of recreation activities are available only for hunting and fishing; these limited data were assessed and estimates made when possible. The results indicate that additional estimates of on-site recreational activities and existence value are necessary for comprehensive management decisions.

MORGAN-MONROE-YELLOWWOOD COMPLEX

The HEE is centered in the MMYC, managed by the Indiana Department of Natural Resources (IDNR)-Division of Forestry (DoF) as a unit with a single supervisor. Understanding the economic, social, and cultural roles of the MMYC requires an understanding of the context in which it is located and managed.

The MMYC includes 19,152 ha of land and 61 ha in four lakes. The largest at 54 ha is Yellowwood Lake, used intensively for fishing and as the setting for picnicking and limited camping. The 132 km of maintained trails range from 0.8 to 68 km in length. There are also 34 km designated as horse trails. This infrastructure accommodates a large, but unquantified, level of recreational use.

The MMYC is the northern boundary of the most heavily forested region of Indiana. Parcels constituting the MMYC lie in Morgan, Brown, and Monroe Counties (Kalb and Mycroft, this publication). Approximately 54 percent of these three counties is forested. If Morgan County is excluded, 66 percent is forested, compared with the statewide average of 15 percent.

The MMYC lies within the Highland Rim Natural Region, bounded on the north by the Martinsville Hills Region, on the east by the Scottsburg Lowland, on the south by Mitchell Plateau, and on the west by Crawford Upland (Homoya and Huffman 1997). The Martinsville Hills Region lies at the southern edge of Indiana's glaciated region. It was formed primarily by the erosive and channeling action of glacial outwash. It is characterized by ridges and hollows that provide scenic variety for recreation activities, but also management challenges to maintain the environmental quality established by reforestation following exploitation of the MMYC lands during the early 20th century (Carman, this publication; Jenkins, this publication).

Spatial Aspects

State Road 37 (SR 37), a four-lane highway with at-grade crossings except in the Bloomington area, provides easy travel between Indianapolis and Bloomington and direct access to the MMYC. Extensive housing development is occurring, driven by SR 37 improvements in Johnson County, directly north of the MMYC. Development may speed up when the

Interstate 69 north-south corridor overlapping the SR 37 corridor is completed. The MMYC is the southern boundary of this development. Recreational use of the forest is expected to increase dramatically with population density. This increased use will change the usage balance between residents in the immediate vicinity of the forest and those driving in from up to 80 km away. Development of a trail system connecting Martinsville to the MMYC is expected over the next 10 to 15 years. This development will result in usage pressures in the northern MMYC similar to those currently experienced from Bloomington and Nashville residents and visitors on the southern edge of Yellowwood State Forest adjacent to Brown County State Park.

It is likely that repeat recreational users of the MMYC have favorite sites and trails although researchers have not explored this topic. The value of some recreation activities should not be extrapolated to the entire MMYC. However, value is added for those using their favorite sites from knowing that these sites are part of a larger forest. Those stakeholders whose primary use is scenic drives focus on management of roadside vegetation and scenic vistas.

Harvest levels, the so-called allowable cut, are based on timber surveys and growth estimates for the entire ownership. Recreational use, however, may limit the area to which the allowable cut can be allocated. Most casual recreational use is concentrated along trails and minimally developed sites. Hunting activities are carried out with a roadway as the base point. Gatherers of mushrooms and other non-timber forest products typically have favorite sites, spread across a broader area than trail hikers (Hembram and Hoover 2008). Information about the location of these activities and the manner in which they are carried out is limited to casual observations by DoF employees.

Access and Policing Aspects

Based on characteristics defined by McKean (2000), the MMYC is a common-pool resource in terms of access by recreationists. Common-pool refers not to the physical characteristics of a resource, but “institutional arrangements for the cooperative (shared, joint, collective) use, management, and sometimes ownership of natural resources” (McKean 2000: 27). She defines this category as “goods that can be kept from potential users only at great cost or with difficulty but that are subtractable in consumption and can thus disappear” (McKean 2000: 28). Timber can be characterized in practical terms as a private resource because state statutes authorize harvesting.

Vehicular access is restricted to paved county highways, reducing the possibility of timber theft. Forest roads are gated, allowing only foot traffic. Neighbors watch for timber theft and other inappropriate activities. Non-timber forest products, primarily herbaceous species, are open access because it is not practical to police gathering, even of controlled species. Stripping of bark from live trees is a minor problem in the MMYC, unlike locations in other parts of the Central Hardwood Region (Hembram and Hoover 2008). Use of recreational sites in high demand, such as Yellowwood Lake and picnic shelters, is monitored by MMYC employees and conservation officers on call to enforce regulations. Self-registration is required for use of campsites, all of which are primitive. The level of compliance is unknown. Hunters have open access except for marked safety zones.

Owners of tracts bordering the MMYC are primary stakeholders. In a mail survey of Indiana forest landowners, Broussard[2] (2006) broke out respondents from what she called the Brown County Hills Area, which includes the MMYC. She found that 58 percent of the responding owners classified themselves as conservative and had owned their land for 24 years

[2] Broussard, S.R. 2006. Understanding your perspectives: a survey of Indiana forestland owners. Unpublished report. 50 p. On file with: Purdue University, Department of Forestry and Natural Resources.

on average. Respondents in the Brown County Hills Area were the least likely of the five areas surveyed by Broussard to have goals for their land. Sixty-seven percent of Brown County Hills respondents included timber production as a goal. Even more, 75 percent, also had some aspect of wildlife as a goal. However, only 22 percent had sought professional help in managing their land. Less than one-half of the owners had ever sold timber. This characterization presents challenges for the development of collaborative management plans across boundary lines.

POLICY FRAMEWORK

Estimating the value of natural resources, especially when defined as complex ecosystems, is more than an academic exercise. All resources are limited and have alternative uses. Decisions about the rate of consumptive and non-consumptive uses are determined by comparing the benefits and costs of alternative uses and management regimes. A major tradeoff is between timber revenue and how managed forests are visually perceived by recreational users (Rogers et al., this publication). The value estimates made here will not allow policy makers to conduct a complete comparison of costs and benefits for alternative management regimes. Because data are available, market-based direct benefits from timber harvesting are discussed in detail. Estimates of the direct costs to grow and market timber from the MMYC are accessible. The management benefits and direct and indirect costs from knowledge of non-market benefits and associated costs are discussed and quantified to the extent possible with the data available.

Protected Areas Classification

Although Indiana's state forests are not generally considered to be protected areas, they could be so considered under the classification system used by the International Union for Conservation of Nature (IUCN) (Dudley 2008). The primary focus of IUCN's protected areas program is developing countries, but the paradigm developed is applicable to the MMYC.

There are six IUCN Protected Areas and World Heritage Program land-use categories: I - strict nature reserves/wilderness areas, II - national parks, III - natural monuments, IV - habitat/species management areas, V - protected landscapes/seascapes, and VI - managed resource protection areas. Bringing the MMYC initially under Category VI classification would increase the interest of the research community and forest users in the HEE research program, as well as in how the MMYC is managed. This classification would complement the existing Sustainable Forestry Initiative and Forest Stewardship Council certifications awarded to Indiana's State Forests.

The HEE could provide the scientific basis for reclassifying the MMYC from Category VI, an area managed for the sustainable use of natural ecosystems, to Category IV, an area managed mainly for conservation through management intervention. Category IV is defined as an "area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats and/or to meet the requirements of specific species." The management objectives for Category IV lands are (1) to secure and maintain the habitat conditions necessary to protect significant species, groups of species, biotic communities, or physical features of the environment where these require specific human manipulation for optimum management; (2) to facilitate scientific research and environmental monitoring as primary activities associated with sustainable resource management; (3) to develop limited areas for public education and appreciation of the characteristics of the habitats concerned and of the work of wildlife management; (4) to eliminate and thereafter prevent exploitation or occupation inimical to the purposes of designation; and (5) to deliver such benefits to people living within the designated area as are consistent with the other objectives of management (Dudley 2008). Raising the classification of the MMYC to Category IV based on HEE research results and subsequent adjustments of management strategies could be a longer-term management goal.

What Determines Value?

Value exists when an institution or people recognize that “property” in some way provides them with a benefit within the context of the relationship between the subject and object (Sheil and Wunder 2002). It is necessary to clearly specify the context and terms of assessment for estimated values to have meaning in a policy framework. Many disputes over management derive from a lack of such an understanding.

“Property” for purposes of this discussion means all attributes of the MMYC, and everything associated with it directly and indirectly. The term “ecosystem” best captures the intended meaning. An ecosystem has static values because of the mere presence of its components at a given point in time, and dynamic values determined by the resiliency and systematic interactions of its components, and with the larger landscape and airshed in which it exists.

Property also refers to place. People dramatically impact the places where they live and work, but place also defines in part who they are (Hawley 1986, Schama 1995). Quality of life for many is determined in large part by where they carry out their lives. Adequate wealth allows many to choose where they live and work. Natural landscapes close at hand are important to many residents’ choice of where to live. The MMYC defines the sense of place for many residents in the vicinity of the MMYC. In addition, the location of privately owned tracts within the general area of the MMYC creates value for the owners of these tracts.

The value of the MMYC derives in part from the wilderness roots of residents and visitors. These roots create in them a so-called pioneer spirit, a drive to overcome obstacles. This spirit is associated with historical heroes, such as Daniel Boone in the East and Kit Carson in the West. We are allowed to hunt on most of the “king’s” (public) land and add the fruits of success to our larder. The collection and use of weapons is ingrained in the culture of many, especially rural, residents. Country and western music, at least in its original form, recalls the pioneer spirit for many. When those with a choice prefer to reside in a rural rather than urban landscape, Bunce (1994) ascribes that preference to a vestige of our tie to the wilderness our ancestors overcame, and a desire to live a rural lifestyle, even if done on a riding mower.

The center of Indiana’s pioneer spirit is Brown County, home of Nashville, where forests and rural landscapes are celebrated in art, music, and treks in Brown County State Park, or the MMYC for those taking a path less traveled. The value of this area is defined primarily by its forest cover. This value is reflected in highly prized and high-priced second homes in the woods and short-term visitors’ expenditures.

Intrinsic and Cultural Values

The intrinsic value of the MMYC is the most difficult for some stakeholders to appreciate because of its basis in moral judgments of right and wrong. The logic used to make moral judgments has the same philosophical basis as the scientific method. Both make observations, apply logic, and draw conclusions. The naturalist philosophy holds that the scientific method should be used for the investigation of all areas of reality, even the “human spirit” (Zalta 2007).

A focus of the HEE is the impact of increased timber harvests to increase early successional habitat, and the best silvicultural systems to use for desired outcomes. Most stakeholders value forests in static terms, i.e., what they see when they return to their favorite trail or campsite. Stakeholder support for managing for early successional habitats should be based on explanations of forest dynamics, i.e., a forest as a constantly changing environment. Acceptance of this need requires that stakeholders accept the need for a mix of habitat types. The discussion is commonly framed in terms of increased population of specified bird species. A stakeholder is asked to accept the value of target bird species and to accept the following reasoning: These species require early successional forest habitat, this habitat is not adequate on other lands to support the desired population levels of the target species, increasing the habitat will increase the population of the target species, and the value of this increase is greater than the value of the default condition of no harvesting. The no-harvest alternative substantially reduces signs or even knowledge of human interference in the progress of the forest toward biological senescence, usually described as old growth. The value judgment is that a higher population of the target species is more important than allowing the progression toward an old-growth state.

The truths of all the elements of this logical chain are subject to hypothesis tests, but rejecting all the null hypotheses would not eliminate the need for individual stakeholders to make their final value judgment. Therefore, policy makers must somehow weigh the implications of the value judgments made by stakeholders. It would not be valid to base management decisions entirely on the scientific evidence proving that a larger area of early successional forest in the MMYC is more valuable than an old-growth state.

Many people ascribe spiritual values to forests. Such values can best be described in philosophical terms. Because it is difficult to capture this value in setting land-use and forest management policies, conflicts often arise among parties advocating policies focused on the extremes of spiritual and market values. For many stakeholders the MMYC represents a new Arcadia, a state of mind that can exist without being physically experienced. Arcadia may take form as Wordsworth’s formal English garden, Thoreau’s Walden Pond on the edge of a New England town, Ansel Adam’s images of El Capitan, or even second-growth forests in Indiana. Treating the MMYC as a new Arcadia is an approach hard to accept for those who read the land in detail across decades.

Aesthetic Value

Aesthetic value exists at a personal level through a psychological response when the observer perceives beauty in the subject (Rolston 1995). The subject may exist physically or conceptually. Value arises when the viewer is willing to expend time and effort to be afforded the opportunity to partake of the beauty in some form. Time and effort are directly associated with money, a medium of exchange, that can be exchanged for experiential opportunities.

Instrumental Value

Something has instrumental value when it plays a role in making something possible. An individual tree has instrumental value with regard to its conversion to a different form, e.g., a wood product. This value is represented by market value. Market value is an instrumental value, i.e., the value that can be derived from the use of an object. Goods and services that are to be sold at their fair market value are offered for sale in an open market where all potential buyers are aware of the offering and have full knowledge of the characteristics of the good or service, any restrictions on its use, and any other factor that would affect its value to a bidder. An assessment process is used to estimate fair market value, and the assessed value may be set as a minimum acceptable price by the seller. Few markets are perfect in this sense, especially when the seller is an agency of government subject to political influence and rent-seeking activity. Timber sales on the MMYC are made using a sealed-bid process; therefore, rent seeking is not a concern.

A forest also has instrumental value as a system that is more than the sum of its parts. Ecosystem service values are now widely recognized, but monetized to a very limited extent (Salzman 2005).

Market Value

The market value of forest land, as with land generally, is derived primarily on the capitalized stream of benefits that the land is expected to generate over a defined time period, often infinite. Economists refer to a stream of benefits as rent in classical economics. Rent can be from timber harvests, hunting rights, non-timber forest products, and payments for environmental services, such as carbon sequestration. Some benefits are public, accruing to all without one person's use diminishing the amount available to others. Other benefits accrue to a small group of users other than the outright owner. The benefits accruing to an outright owner are limited to those for which they have secured rights. Land rights refer to the holder's ability to capture this stream of benefits. Benefit streams not captured by the holder result in undercapitalization of the true value of the land and conversion to land uses with higher monetized benefit streams (Wunder 2005).

In the major timber-producing regions of the United States, the market value of forest land may similarly be determined by its capacity to produce periodic crops of timber. However, estimates are complicated by the need to determine optimal periodicity (Samuelson 1976). Aronow et al. (2004) estimate that two-thirds of the total returns from timberland are from appreciation in the value of the land itself, timber volume growth, and timber prices. Although lumber price-reporting services have been available since shortly after World War II (e.g., Random Lengths [2010]), reporting of forest land prices did not start until institutional investors became interested in the advantages of forest land for portfolio diversification (Conroy and Miles 1989). Several major life insurance companies had timberland in their portfolios as early as 1950 (Binkley et al. 1996). The need for vertically integrated forest products manufacturers to capture the value of their timberland holdings for stockholders made large holdings available to institutional investors and later to private equity investment groups that accumulated capital for purchases of timberland contracted for management services from timber investment management organizations.

Although an early application of modern portfolio theory to forest investments considered returns from agriculture and timber in Indiana (Mills and Hoover 1982), forest land sale prices were not available for this analysis. Market values of crop land are reported by Purdue University's Department of Agricultural Economics (Dobbins and Cook annual), but prices paid for forest land are not reported. Detailed delivered log price data have been available since 1957 (Hoover and Preston annual) and are used to calculate a price index for trend monitoring. This index can be used as a proxy for financial returns from holding timber, exclusive of volume growth and increases in land value. Based on the index for a high-quality stand of timber, the real annual rate of return is declining on average (Fig. 1). The year-to-year rate of return from holding timber for another year was 2.75 percent for 1957 to 1958. From 2009 to 2010 the rate was -0.002 percent. Between 1957 and 2010, the standard deviation of returns was 0.876. Variation increased substantially after the recession in the mid-1970s, when price inflation of commodities, including forest products, began to trend upward.

There is no basis for estimating the liquidation value of the MMYC land considering the area held. Liquidation value would provide an estimate of the lost one-time revenue and associated opportunity cost incurred

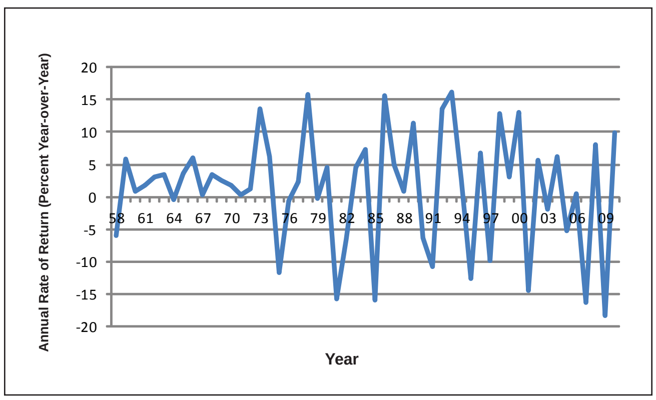

Figure 1.—Annual rate of return from holding timber in Indiana.

by holding the land, but there is no commercial timberland in Indiana to use for comparable sales. Commercial forest land in this context is generally defined as tracts of forest land large enough to attract institutional and private equity investors. A few large hardwood lumber and veneer producers own upwards of 4,047 ha each in scattered tracts of 4 to 81 ha. An additional indication that these lands are not part of a commercial timberland pool is that they are generally held for decades, not turned over periodically to provide cash flow for dividend payments. Large tracts of commercial timberland are open for hunting and other recreational uses in many states. The lack of such lands places additional pressures on public forest land in Indiana.

The U.S. Department of Agriculture, Forest Service (USFS), Forest Inventory Analysis (FIA) conducts an ongoing survey of forest land but no longer attempts to estimate the amount of timberland owned by "forest industry." Timberland is defined for the FIA assessment as forest land capable of producing more than 20 cubic feet per acre (49 cubic feet per ha) per year of industrial wood crops under natural conditions. The last estimate of industry ownership was made for 1998. Of the total 1,757,266 ha of timberland in Indiana, forest industry was estimated to own 7,042 ha and corporations 385,000 ha. In the Knobs FIA unit where the MMYC is located, 3,076 ha were classified as owned by forest industry and 45,365 by corporations. The Knobs Unit includes 694,967 ha, 40 percent of the timberland in Indiana.

Recreation Value

The place where many outdoor recreation (OR) activities occur is as important as the activity itself. The scale of OR venues varies greatly, but many of the most commonly engaged-in activities require large areas. These venues can be linear, such as urban and inter-urban trails, or a large contiguous area such as the MMYC. Recreationists desiring an experience in a more primitive area, such as large blocks of forest land, do not want to have any indicators of development within view. Many also receive pleasure knowing that they are some distance from development and have viewscapes consisting primarily of forests.

The scenic quality of landscapes constitutes a recreational resource (Dearden 1980). Driving through a scenic landscape to reach a venue can create anticipation for what will happen upon arrival, or the drive itself may constitute the activity. A trip to and from the Smoky Mountains, Grand Tetons, or similar areas can be the substance of the activity. For those heading south from Indianapolis on SR 37, the forested ridges immediately south of Martinsville (the northern edge of the MMYC) are the introduction to the most heavily forested area in Indiana. The paved roads through the MMYC are used as scenic byways. The northern edge of the MMYC thus has greater scenic value than those State Forests embedded in the more extensively forested landscapes farther south.

The landscape and interior viewscapes necessary to achieve a desired effect, perhaps best described as a sense of place, are personal. At one extreme are true wilderness areas that allow hikers to be totally out of contact with others for days. Although Indiana has a designated wilderness area, it does not equal the large areas usually envisioned. At the other extreme might be Indiana's State Parks, which are void of almost all manipulation of the terrain and vegetation, but restrict users to designated pathways and intensive-use areas. The MMYC is different because it is actively managed and allows unrestricted movement. Most visitors, however, take advantage of the trail network.

Statewide Outdoor Recreation Plan

The IDNR-Division of Outdoor Recreation conducts periodic surveys of the general population and of individuals engaging in specific OR activities. The results are used as the basis of the Indiana Statewide Comprehensive Outdoor Recreation Plan (SCORP).

The most recent plan covers the period 2006-10 (IDNR-Division of Outdoor Recreation 2007). SCORP ensures that Indiana is eligible for federal funding under the Land and Water Conservation Fund Act of 1965. Equally important, SCORP provides guidance to all public and private OR providers.

Outdoor recreation is an integral part of the lifestyles of a majority of Indiana individuals and families. The OR participation survey of the general public conducted for SCORP indicated that in 2003 OR activities were "essential" to 54 percent of respondents. Eighty-five percent participated in walking/hiking/jogging activities. The second most frequent activity category was fairs/festivals at 68 percent. SCORP states that the large spread between these two leading activity categories in terms of participation indicates a "tremendous need for trails and other linear activity opportunities" (IDNR-Division of Outdoor Recreation 2007: 23). Other frequent activities were in the swimming/SCUBA/snorkeling category at 60.7 percent, nature photography (59.8 percent), camping (53.5 percent), and fishing (52.3 percent). Most respondents reported engaging in activities within more than one category, and more than one activity within a category.

The MMYC is a venue for all of the most important OR activities reported by Indiana residents. The most frequent activity, walking, was broken down in the SCORP report into types of walking, with walking for pleasure undertaken by 78 percent, and hiking by 39 percent of respondents. Most frequent activities in the nature observation/photography category were wildlife viewing by 55.1 percent and fall foliage viewing by 53.2 percent of respondents. The camping category was led by tent camping at 63 percent, greater than RV/trailer camping at 34 percent. In the hunting category, deer hunting dominated at 72.3 percent. Eleven percent indicated that they participated in horseback riding.

The MMYC's proximity to Indianapolis, the state's major population center, and the large active young-adult population in the Bloomington area increase its recreation value. The 2003 OR participation survey did not include questions related to how far respondents were willing to travel to participate in an activity. It did, however, ask a question about acceptable length of travel time to reach a new or improved OR facility. Thirty-three percent were willing to travel for 16 to 60 minutes, 21 percent 60 to 90 minutes, 17 percent 2 hours, 6 percent 3 hours, and 12 percent more than 3 hours. The authors indicated that the disparity in the last two categories may be due to respondents' distinguishing between partial-day activities and all-day activities. The participation survey did not differentiate between day-use facilities and destination facilities. The latter is a facility for which a majority of the users stay over at least 1 night (Van Doren et al. 1985). They also found that "most households repeatedly use a single facility and that there are significant behavioral differences between those who visit a single facility and those who go to a variety of places" (Van Doren et al. 1985: 17).

ESTIMATES OF VALUES OF THE MMYC

Forest Recreation

It is necessary to use secondary sources to estimate the potential monetary value of the MMYC for OR activities. If survey data for the number of visits and segment type were available, these secondary data could provide rough estimates of recreation expenditures. Given the proximity of the Hoosier National Forest (NF), survey data for that forest from the USFS's National Visitor Use Monitoring (NVUM) program should be informative. The first full cycle of the NVUM (Stynes and White 2005) program was conducted from January 2000 to September 2003. The survey uses standardized definitions of "national forest site visits" and "national forest visits." The former is the entry of one person upon a National Forest site or area to participate in recreation activities for an unspecified period of time. The latter is the entry of one person upon a National Forest to participate in recreation activities not at specific sites and not for a specified period of time. Thus, an NF visit could consist of more than one site visit. A "viewing corridor visit" is the entry of one person onto a travelway, such as a road, trail, railroad, or river that is neither owned nor managed by the USFS, for the purpose of viewing scenery on USFS lands adjacent to the travelway.

The NVUM data are used to develop spending profiles for NF use (Stynes and White 2005). Because of small sample sizes for individual forests, a weighted average profile is developed based on the survey data for high and low categories. The Hoosier NF is in the low category. Expenditure estimates were made for seven visitor trip type segments: (1) Non-local day trips – non-local residents on day trips; (2) Non-local OVN-NF – non-local residents staying overnight on the NF; (3) Non-local OVN – non-local residents staying overnight off the NF; (4) Local day trips – local residents on day trips; (5) Local OVN-NF – local residents staying overnight on the NF; (6) Local-OVN – local residents staying overnight off the NF; and (7) Non-Primary – visits where recreation on the NF is not the primary trip purpose. The average expenditure profiles by segment for the low category are presented in Table 1. Sixty percent of visits to the Hoosier NF were in the local day visit segment (Table 2). The number of visits to the MMYC in this segment category are likely proportionately higher given its location and activities available. The average number of people per vehicle visiting the Hoosier NF was 2.4 (Table 2).

Table 1.—Low spending profiles by segment and spending category, $ per party per trip. Source: Stynes and White (2005: Table 8). OVN-NF – overnight on national forest, OVN – overnight not on national forest.

	Non-local segments			Local segments				
Spending category	Day	OVN-NF	OVN	Day	OVN-NF	OVN	Non-primary	All visits
Lodging	0.00	13.56	41.71	0.00	10.03	12.27	30.81	12.49
Restaurant	11.72	14.91	42.08	5.75	9.18	16.68	27.25	16.25
Groceries	6.90	26.89	20.70	4.31	34.79	16.53	17.88	12.85
Gas & oil	12.63	29.26	29.29	11.84	24.28	22.41	19.71	18.47
Other transportation	0.43	1.12	5.68	0.21	0.00	0.32	5.94	1.73
Activities	3.27	3.04	9.65	1.77	2.46	9.19	1.61	4.03
Admissions/fees	4.30	7.52	7.25	3.54	8.50	8.01	3.15	5.17
Souvenirs/other	2.05	10.42	15.06	2.29	6.96	7.17	12.14	6.58
Total	41.29	106.72	171.42	29.71	96.20	92.59	118.48	77.56
SE Mean of Total	2.62	5.05	8.97	0.98	4.35	6.51	9.54	1.48

Table 2.—Estimates specific to Hoosier National Forest. Source: Stynes and White (2005: Tables A-2 and A-3).

	Non-local segments			Local segments				
Spending category	Day	OVN-NF	OVN	Day	OVN-NF	OVN	Non-primary	Total
Segment shares (%)	13	12	2	60	9	1	3	100
People per vehicle		2.9		2.4	1.7			2.4

Wildlife

The value assigned to wildlife is critical for evaluating tradeoffs among management alternatives impacting timber and wildlife. Values assigned to wildlife affect how available resources are allocated to the habitat for and management of wildlife generally and for target species (Berryman 1987). Managing for abundant deer for hunting, a major recreational use of the MMYC, involves significant tradeoffs with timber regeneration. A variety of forest successional stages increases the number of bird species, but lacking estimates of MMYC recreationists focused on observing a variety of species, it is difficult to evaluate this component.

Benefit-cost analysis, requiring estimates of dollar values, is commonly used to evaluate wildlife management tradeoffs (Stevens et al. 1991). Values most commonly used are use values and existence values. Use value is derived from hunting, fishing, and viewing activities that place the recreationist on site. Existence value accrues to both users and non-users when the value is attributable to those receiving value from the mere existence of wildlife. The primary source of use value estimates is the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation conducted every 5 years by the U.S. Department of Commerce in cooperation with the U.S. Fish and Wildlife Service (U.S. Department of the Interior, Fish and Wildlife Service and U.S. Department of Commerce, Census Bureau 2008).

Given the absence of a market, existence value must be measured indirectly, typically using a contingent valuation method (CVM). Weisbrod (1964) first developed the notion that non-users of wildlife may still get value from it and would be willing to pay an option price to retain the possibility of using the resource in the future. Krutilla (1967) introduced the theory that non-users may value a natural resource they have no desire to use, giving it an existence value. An existence value may also derive from a wish to endow future generations; this value is an altruistic value from knowing others can enjoy the resource, while others place an intrinsic value on a resource.

The 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. Department of the Interior, Fish and Wildlife Service and U.S. Department of Commerce, Census Bureau 2008) estimated that 3.1 million U.S. residents fished, hunted, and watched wildlife in Indiana (Table 3). The total overestimates the number of individuals because some carry out more than one activity. Expenditures per hectare for the state can be obtained by applying these estimates to the area of land in Indiana suitable for each activity. The per-hectare values can then be applied to the area of the MMYC to get rough estimates of expenditures attributable at least in part to activities in the MMYC.

Table 3.—Activities in Indiana by U. S. residents. Source: 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. Department of the Interior, Fish and Wildlife Service and U.S. Department of Commerce, Census Bureau 2008) and extrapolations by author. TEENR = trip and equipment expenditures by non-residents.

	Fishing	Hunting	Wildlife watching	Total
Participants	768,000	272,000	2,042,000	1,795,000
Days	9,805,000	4,808,000	24,013,000	38,626,000
Trip related expenditures	$242,624,000	$65,550,000	$143,615,000	$451,792,000
Equipment expenditures	$384,543,000	$157,470,000	$790,305,000	$1,335,318,000
TEENR	$120,464,000	$31,639,000	$45,511,000	$197,614,000
Estimates by author				
$/ha of water or land	$444.31	$3.27	$25.19	$28.40 for land
MMYC area	$66,650	$64,000	$495,800	$626,600

The 2007 National Resources Inventory (NRI) (U.S. Department of Agriculture 2009) estimated that there were 8,264,102 ha of non-federal rural land, plus 196,506 ha of federal land in Indiana. Because most of the federal land is open to hunting, the total private and federal land theoretically available for hunting is 8,460,607 ha. Assuming that one-half of this land is actually hunted, the area hunted would be 4,230,304 ha. The 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation estimates that resident and nonresident hunters spent $254,662,000 for travel and equipment in 2006. This makes the expenditure per ha for hunting $60.20 ($254,662,000/4,230,000 ha). Based on the 13,837 ha used for timber production on the MMSF, the hunting value would be $833,000.

The same survey estimated that resident and nonresident wildlife watchers spent $979,413,000 in Indiana in 2006. Assuming wildlife watching is possible on all 8,264,102 ha of rural land plus on a portion of urban land, the expenditure per ha is $119 ($979,431,000/8,264,102). If this expenditure is applied to the entire 16,279 ha of the MMYC, the wildlife-watching value would be $2,269,824. This value would capture a majority of the day hikers using the MMYC.

The 2007 NRI (U.S. Department of Agriculture 2009) estimated that there are 155,200 ha of water in Indiana. Assuming that 50 percent is available for fishing, the hectares fished would be 77,600 ha. The Survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. Department of the Interior, Fish and Wildlife Service and U.S. Department of Commerce, Census Bureau 2008: 4) estimated that fishing-related expenditures by residents and nonresidents totaled $747,631,000. This gives a per-hectare value of $9,634 for water fished ($747,631,000/77,600 ha). This assumption would make the value of the 61 ha of lakes in the MMYC $587,701. Multipliers for determining total economic impact of wildlife are needed to make these values comparable to the estimated impact of timber revenue.

Ritz and Ready (n.d.) conducted a comprehensive analysis of the marginal cost and benefit of a deer in Pennsylvania. Costs included Lyme disease; deer-vehicle collisions; damage to landscaping and nurseries; crop damage; and damage to forests, the timber industry, and ecosystems. They estimated that 1 out of 12 state residents takes out a hunting license. They estimated marginal benefits for a one-deer increase in the total deer population from hunting of $91 to $107 per deer and from viewing of $7 to $116; total costs ranged from $150 to $232. The implication is that the size of the deer herd should not be increased, because at the high end of the estimates costs exceed benefits. At the low end of the estimates, the benefits from adding an additional deer outweigh the costs.

The IDNR-Division of Fish and Wildlife reports the deer kill by county (Stewart 2010). The deer harvest was 1,480 and 1,968 in Monroe and Brown Counties, respectively. Reports by MMYC property personnel of nearly bumper-to-bumper parking on MMYC roads during hunting season indicate that state forest land is hunted more heavily than private land because no permission is needed to hunt on State Forests and the area of private land open for hunting has declined, in part due to leasing. Monroe County is 1,020 km^2 and Brown County is 821 km^2. The MMYC constitutes about 10 percent of the land area of Brown and Monroe Counties combined. It constitutes about 15 percent of the forested area of these counties. Applying the forest cover percentages for each county to the deer take yields a deer take in the MMYC of 400 to 500 per year.

Contingent Valuation

The most likely alternative for measuring non-market values is contingent valuation. Stevens et al. (1991) developed a utility function to test the validity of the contingent valuation method for estimating the existence value of four species introduced or reintroduced to New England—bald eagle (*Haliaeetus leucocephalus*), Atlantic salmon

(*Salmo salar*), wild turkey (*Meleagris gallopavo*), and coyote (*Canis latrans*). They found that their results were consistent with previous work, but noted the frequency with which respondents to their survey instrument expressed moral beliefs which are not measurable in monetary terms. They adopted a general form of a utility function that includes an individual's own consumption of a bundle of private goods, knowledge of others' use, personal existence value, and knowledge that others derive satisfaction from knowing of the existence of the resource. These independent variables fall into three categories: (1) personal use values, (2) use by others, and (3) non-use value. Economists' main concern is the possibility of bias in responses and the extent to which economic theory applies.

Harris et al. (1998) questioned the decisionmaking process of respondents to surveys. Specifically, they questioned whether respondents consider the price of substitutes available in the market or non-market, whether income constrains responses, whether the process of responding to questions creates a stressful circumstance, whether respondents are familiar with the resource in question, or whether any possible decision is inconsequential to a respondent. Finally, a respondent may consider a resource priceless because of spiritual or moral rights he or she assigns to the resource. A further complication noted by Mitchell and Carson (1989) is that wildlife existence is a public good for which the supply cannot be explained by neoclassical economics. Stevens et al. (1991) found that 79 percent of respondents to their salmon survey agreed with the statement "All species of wildlife have a right to exist independent of any benefit or harm to people." Seventy percent of respondents gave this statement as one of the three most important reasons for the existence of bald eagles, wild turkeys, and coyotes.

Stevens et al. (1991) found a positive relationship between respondents' level of formal education and willingness to pay for bald eagles, wild turkeys, and coyotes. They also found a positive relationship between respondents' expectation that they would fish for Atlantic salmon in the future and their willingness to pay for salmon restoration. The option value and willingness to pay for coyote were the lowest of the four species. Their estimated equivalent surplus willingness to pay was $7.93 for Atlantic salmon. Boyle and Bishop (1987) estimated $1.00 to $5.00 for striped shiner (*Luxilus chrysocephalus*), a non-game fish. Kay et al. (1987) estimated Atlantic salmon existence value of $10 to $30 above the willingness to pay for fishing licenses. Only 6 percent of respondents to the salmon survey selected either a current or future use as one of the reasons for preservation of this species. Only 12 percent of those responding to the surveys for the other three species selected either current or future use as reason for preservation in New England. Stevens et al. (1991) estimated bald eagle equivalent surplus of $19.28 per person per year; estimates within the $10.62 and $75.31 range were reported in other studies they cited.

Research

Though difficult to value in dollar terms, the use of the MMYC for research is arguably its greatest value to the nation. Its location less than 25 km north of Bloomington, IN, home of Indiana University, has led to extensive use for research. Researchers from Ball State University and Purdue University, among others, have conducted research here. The complex provides unique opportunities to conduct research because of the large areas of contiguous forest cover.

Terrestrial Data

The MMYC plays a critical role in the study of the biochemical systems of deciduous forests using data from NASA's "moderate resolution imaging spectroradiometer" (MODIS) satellite imagery focused on representative vegetative sites throughout the world. The MODIS data are correlated with complex ground-level data collected from AmeriFlux towers, one of which is located on the MMYC. "The core of the MMYC AmeriFlux project is a joint assessment of the role of this forest ecosystem as a net carbon sink by micrometeorological (eddy-flux, EC[3]) and biometric (carbon-pool increments) methods. The site regularly collects data about CO_2 exchange between the atmosphere and the forest, as well as many other variables necessary for understanding the carbon dynamics in deciduous forests” (Indiana University 2009: homepage).

Data from the MMYC are compared with those of other MODIS-AmeriFlux sites to assess the role of forests globally to sequester carbon. Ground, vegetation layers, air composition, and meteorological data are collected at these sites and correlated with spectral signatures to provide the relationships required to draw conclusions on carbon flux and other critical environmental factors determined primarily by vegetative cover. The ability to access these data has led to millions of dollars in research grants to Indiana universities.

A brief search of the academic literature revealed that more than 100 scientific journal articles have resulted from research projects using data from the MMYC. Journal articles started to appear 6 years after the founding of MMYSF in 1929.[4] Research reported includes remote sensing and carbon flux modeling, extent of and control of invasive species, wildlife, forest regeneration, entomology, landscape modeling, botany, mensuration, and soils.

Timber Sales

The MMYC primarily supports the wood products industry within 58 km of the center of the forest. This estimate is based on the 41 percent of the volume sold from 1993 to 2010 for which the buyer’s city was recorded. The longest haul was 172 km for a white oak (*Quercus alba*) veneer sale. Hoover and Preston (2010) reported that statewide the average haul distance is about 80 km. In 2005 sawlog production of all species in Brown, Monroe, and Morgan Counties was 33.2 million board feet (Piva and Gallion 2007). The volume sold from the MMYC forests in 2005 was 1.6 million board feet. Thus, the MMYC accounted for 4.8 percent of total sawlog production in these counties in 2005. The gross annual economic impact of timber sales for the 17-year period from 1993 to 2010 averaged $94.9 million (Table 4). This total assumes a gross economic multiplier of $51 per board foot (Hoover and Settle 2010).

ECONOMICS OF SILVICULTURAL SYSTEMS

Forest management regimes are selected primarily by owners’ objectives and the evaluation of tradeoffs. The MMYC is heavily used for recreation and research, as

Table 4.—Economic impact of timber volume sold from MMYC State Forests, 1993 to 2010.

Year	Volume sold (MBF)	Gross economic impact
1993	1,340	$68,330,259
1994	1,490	$75,983,115
1995	1,809	$92,246,658
1996	875	$44,608,323
1997	1,390	$70,898,517
1998	1,114	$56,803,188
1999	1,184	$60,377,880
2000	545	$27,795,255
2001	545	$27,795,255
2002	1,081	$55,120,494
2003	1,182	$60,303,624
2004	1,461	$74,514,570
2005	1,794	$91,498,794
2006	5,345	$272,597,958
2007	2,771	$141,301,773
2008	4,453	$227,080,152
2009	3,012	$153,602,106
2010	2,089	$106,515,642
Total	33,480	$1,707,373,563

[3] Eddy covariance
[4] Duncan, W. 1935. Root systems of woody plants of old fields of Indiana. Ecology. 16(4): 554-567.

well as for generating revenue from the sale of timber. The statutory guidelines for management of State Forests provide that:

> Sec. 1. (a) It is the public policy of Indiana to protect and conserve the timber, water resources, wildlife, and topsoil in the forests owned and operated by the division of forestry for the equal enjoyment and guaranteed use of future generations. However, by the employment of good husbandry, timber that has a substantial commercial value may be removed in a manner that benefits the growth of saplings and other trees by thinnings, improvement cutting, and harvest processes and at the same time provide a source of revenue to the state and counties and provide local markets with a further source of building material (Indiana Code 2011).

The selection of silvicultural systems involves significant tradeoffs among timber revenue, biological diversity, and forest users' perception of aesthetic value. The tradeoffs between oak-hickory (*Quercus-Carya*) and maple-beech-birch (*Acer-Fagus-Betula*) forest types are a major theme of the HEE project. These tradeoffs are discussed by Jenkins (this publication).

Composition of Indiana's Timberland

The loss in timber value resulting from the movement away from oak-hickory may be used as justification for creating disturbances sufficient to regenerate oak and associated species. Indiana's primary and secondary forest products industry developed in large part based on the availability of high-quality timber of oak species and black walnut (*Juglans nigra*). Many other species are used, however.

Forest-type groups defined by the USFS were used for analysis of changes in forest type. These are aggregates of forest cover types (Eyre 1980). The oak-hickory forest type group includes 20 forest cover types. The maple-beech-birch forest type group includes four forest cover types (USFS 2007). In 2010 these two forest types accounted for 80 percent of the timberland in Indiana (USFS 2011).

Oak species as a percent of the statewide net tree volume on timberland classified in the oak-hickory forest type decreased from 45.5 percent in 1986 to 30.9 percent in 2010, while hard maple increased from 4.9 percent to 8.4 percent (Fig. 2). The change for the volume of oak species classified in the maple-beech-birch forest type was from 17.7 to 7.5 percent of total volume, while hard maple increased from 22.6 percent to 58.6 percent (Fig. 3). While the percentage of oak species in both forest types declined from 1986 to 2010, the area of timberland classified as oak-hickory forest type increased by 544,989 ha; the area classified as maple-beech-birch decreased by 266,453 ha (Fig. 4). The increase in the area of oak-hickory forest type group is due to the broad range of forest cover types included. In addition, timber harvesting practices on unmanaged timberland are dominated by harvesting of all merchantable timber down to pulpwood size. This activity creates sufficient disturbance to regenerate intolerant species.

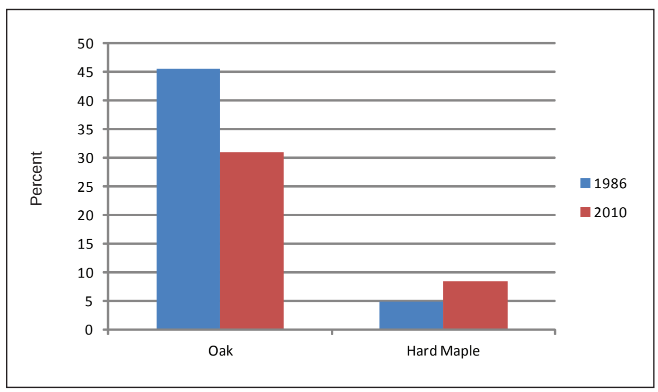

Figure 2.—Oak and hard maple components of oak/hickory forest type group in 1986 and 2010.

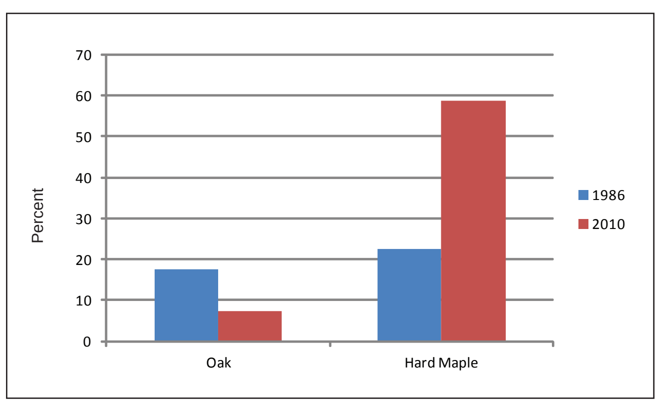

Figure 3.—Oak and hard maple components of maple/beech/birch forest group type in 1986 and 2010.

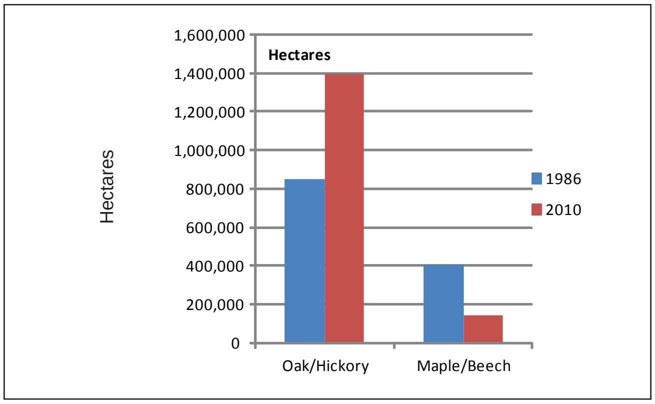

Figure 4.—Hectares of timberland in oak/hickory and maple/beech/birch forest group types.

Timber Value by Forest Type

An indication of the overall economic impact of the change from oak-hickory to maple-beech-birch forest types is a comparison of the historical value of the species mixes for these forest types. The FIA Forest Inventory Data Online calculator for the oak-hickory (400) forest type, and the maple-beech-birch (800) forest type were used to obtain the species mix of these forest types. The species distribution for 1986, the earliest available, was used for the 1957 to 1986 period. From 1986 to 2010 the species weights were based on a straight-line increment between 1986 and 2010. The price data by species and log grade came from the Indiana Forest Products Price Report (Hoover and Preston annual). These reports delivered log prices for 4 grades of sawlogs for 15 species, and 2 grades of veneer logs by log diameter categories using diameter inside bark in inches for 6 species. The average log values used to calculate the price index for an average stand were used; only the species distribution was changed. The values of prime red oak (*Q. rubra*), white oak, and hard maple sawlogs (Fig. 5) follow the same pattern as that for the two forest types (Fig. 6). Stumpage values were not estimated for this analysis because the focus is on the value difference between the two forest types.

The values of these two forest types did not separate until 1974 (Fig. 6), when the rate of inflation increased substantially. That year is also about the time hardwood lumber production cycled up with peak production in 1999 and a decline thereafter (Hoover and Preston 1999). The amount by which the value of oak-hickory forest types exceeded the maple-beech-birch forest type peaked in 1989 at $56 per thousand board feet (MBF). The value of oak-hickory was greater than maple-beech-birch until 2000, bottoming out in 2006 at $125 per MBF (Fig. 7). From 1957 to 1986, the value difference was due to changes in log prices. Thereafter the change was due to both price fluctuations and trends, and species composition changes.

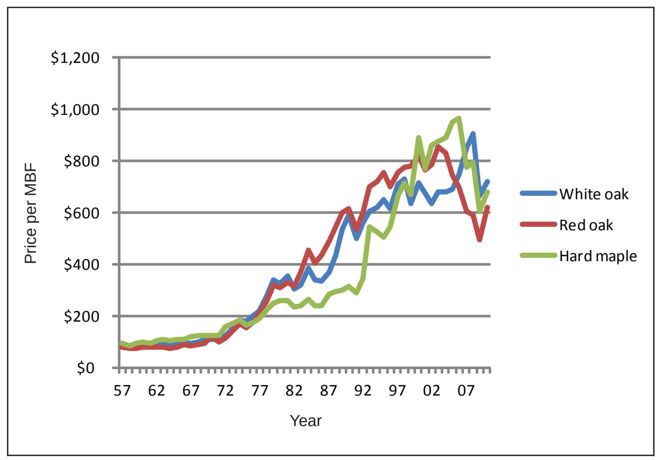

Figure 5.—Price per MBF of prime sawlogs delivered to mills in Indiana, 1957 to 2010. Source: Hoover and Preston (annual).

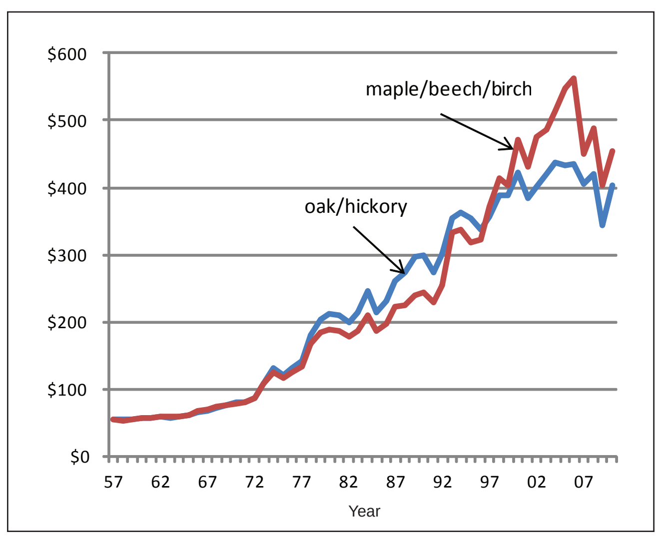

Figure 6.—Value of timber for average stand for oak/hickory and maple/beech/birch forest types.

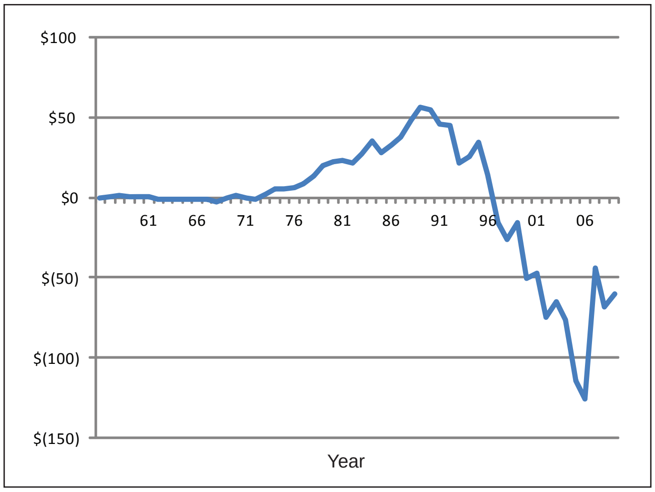

Figure 7.—Price differential between timber value of an average stand classified as oak/hickory and maple/beech/birch forest types.

Relative Price of Oak and Hard Maple

Decisions made today regarding managing for oak-hickory forest types or allowing natural succession are driven by owners' objectives. Long-term relative timber values are most likely not a significant factor for a majority of owners. Butler's (2011) National Woodland Owner Survey Table Maker estimates that the owners of 60 percent of family-owned forest land have "minimal activity to maintain" forest land as an objective. However, the same source estimates that 74 percent of the land is held by owners expecting to "harvest sawlogs or pulpwood" in the future. Thus, it is doubtful that family forest owners seek to maintain oak-hickory forest types. The management objective for state forest land is the maximization of net benefits to society, including biological diversity. Thus, relative timber values inform decisionmakers regarding the net financial benefit of managing to maintain oak-hickory forest types.

The higher value of maple-beech-birch forest types compared to oak-hickory determined for this analysis reflects state-wide average species compositions. This is a recent trend and may change back to equal or higher value for oak-hickory as the supply of oak species decreases due to harvest levels in excess of growth (Woodall et al. 2005), as well as natural succession to maple. As long as the market value of hard maple exceeds that of oaks, there is no financial incentive for private forest owners to manage for oak-hickory.

Oak removals exceeding growth should eventually reverse relative prices unless there is a significant and long-term decline in oak demand. On the other hand, increasing average temperatures will favor oak-hickory while maple decline continues to impact maple volumes in both urban and forest sites (Bauce and Allan 1991, Houston 1999). Considering these numerous interacting factors, this analysis assumes that the relative oak and maple prices will return to the long-run pattern of parity.

Capital Value of Silvicultural Systems

The potential reduction in stumpage value resulting from a change from the oak-hickory forest type group to the maple-beech-birch forest type group does not necessarily mean a reduction in the return on investment when natural succession occurs. Both market and non-market benefits should be considered if the total return to society is the management objective. Management of the MMYC requires balancing the tradeoffs between market and non-market benefits because of uncompensated recreational use. The focus in this section is traditional measures of investment returns from timber production.

The standard approach to evaluating alternative timber management regimes is estimation of the year zero net present value (NPV_0) for each alternative. If the land is to be permanently managed for timber, the appropriate measure is the net present value of a perpetual series of periodic payments (Faustmann 1849), as given in equation (1). The numerator is NPV as of the end of a rotation. The denominator is the multiplier for the year zero present value of a perpetual series of constant NPVs as of the end of the period:

$$LEV = \sum_{t=0}^{n}\left[\left(R_t - E_t\right)\left(1+i\right)^t\right] \Big/ \left[\left(1+i\right)^n - 1\right] \quad (1)$$

where R = revenues, E = expenses, i = nominal discount rate, t = index on years, and n = rotation length. This measure is referred to as soil/land expectation value (SEV/LEV). It reflects the amount that could be paid for bare land if the land is used to generate the net revenues assumed. Although formulated for a continuous series of even-aged rotations, it is applicable to uneven-aged regimes by substituting cutting cycles for rotations (Straka and Bullard 1996). This application requires assuming a continuous series of harvests of equal periodicity, net revenue, and costs, as shown in equation (2) (Straka and Bullard 1996, equation (h)). Equation 2 reflects the amount that could be paid for the land and the level of stocking needed to generate the periodic net revenue:

$$LTEV = \left[NTR - \left(a\left(1+i\right)^{c} - 1 \right) / i \right] \Big/ \left[\left(1+i\right)^{c} - 1 \right] \quad (2)$$

where NTR = net timber revenue received every c years, a = annual management and tax costs, c = number of years in the cutting cycle, and i = nominal discount rate. Given that NTR in equation (2) can be generated only with the land and a base level of timber stocking, “land expectation value” is not an appropriate term. Countryman and Miller (1989) refer to this measure as land and timber expectation value (LTEV).

Countryman and Miller (1989) estimated the investment returns for upland oak stands with sugar maple (*A. saccharum*) understory compared to stands that succeed to sugar maple. At the time of their analysis in 1989 oak stumpage prices were at least 80 percent higher than hard maple, based on the 1989 Indiana Timber Price Report (Hoover 1989). They assumed revenues per ha of $648 (low), $7,770 (medium), and $23,310 (high) for the final harvest of oak clearcutting systems. The comparable values for upland oak stands succeeding to hard maple uneven-aged stands were $130, $389, and $1,554 per ha on a perpetual 10-year cutting cycle. They also modeled an oak shelterwood system. The comparable values for the final cut were $433, $5,180, and $15,540 per ha. They concluded that (1) managing to shorten rotation length increases LTEV because of the end-loading of revenues and front-loading of costs; (2) for higher discount rates, minimizing costs contributes more to LTEV than does a higher-quality stand; (3) in stands with medium to high initial stand values, sugar maple has the highest LTEV because of higher costs associated with oak alternatives; (4) in stands with low initial stand values, oak may have a higher LTEV because these stands generally have low site indexes; and (5) when existing oak stands can be treated before they reach economic maturity, oak LTEV may exceed hard maple LTEV because stand value growth exceeds carrying costs.

The literature lacks clarity regarding the financial analysis of converting among silvicultural systems. Countryman and Miller (1989) assumed that for existing stands with adequate stocking for conversion to uneven-age management, the one-time revenues and costs for conversion were added to the LTEV. For stands with inadequate stocking they added the revenue from the initial clearcutting to the LTEV. These one-time revenues increase LTEV above that for a perpetual series of NPVs. Similarly, Chang (1981) and Rideout (1985) used the term “manage forest value” for the NPV of an uneven-aged stand in its steady state. They added to this amount the NPV of the conversion-period cash flows.

Guldin’s (1996) approach to dealing with the analysis of conversions among southern conifer systems is keyed to the landowner’s objectives. In the case of landowners not willing to liquidate the residual stand required to perpetuate uneven-aged systems, the liquidation value is not carried forward. In other words, the value of the residual stocking that must be carried in perpetuity is not considered as a capital cost, unlike the Countryman and Miller (1989) approach. Not including the capital value of residual stocking would be justified when private landowners receive non-monetized benefits from the continuous presence of stocking.

Silvicultural Model Assumptions

The primary purpose of this analysis is to compare alternative silvicultural systems used in Indiana generally, and the MMYC in particular. These models are relevant only for making per-hectare comparisons. A given model is not relevant to the value of the MMYC as a whole because a mix of silvicultural systems is used.

Even-aged: LEV as presented in equation (1) was used with all costs and revenues compounded to the end of an assumed 80-year rotation.

Shelterwood: Straka and Bullard (1996) do not adapt the LEV model for shelterwood. Countryman and Miller (1989) analyzed shelterwood models by applying equation (1) to each individual revenue and expense with a final shelterwood cut in year 60. This approach is equivalent to modeling a shelterwood system over an 80-year period and applying equation (1) to NPV_{80}.

Single-tree selection model: The formulation of Straka and Bullard (1996) for determination of LTEV is based on a fixed cutting cycle with all revenues and costs replicated in perpetuity. Equation (1) is applied to the NPV at the end of the cycle. This is also equivalent to modeling a shelterwood system over an 80-year period and applying equation (1) to NPV_{80}.

Analysis

Estimates of NPV_0 were made for even-aged, shelterwood, and single-tree selection silvicultural systems using Microsoft Excel (Microsoft Corporation, Redmond, WA). I reported LEV for even-aged systems and LTEV for shelterwood and single-tree selection systems. The spreadsheet was formulated to allow sensitivity analyses for all variables. The measures used to compare systems were NPV_0 and equation (1) applied to NPV_{80}. Assuming an 80-year rotation or cycle makes the specific model used less important because of the small contribution to NPV of revenues and expenses past 60 years and the focus on comparison of LTEVs. The impact does vary, however, by the interest rate used. For example, for the 3-percent discount rate used in this analysis $1 in year 80 is worth $0.09 in year zero.

Sets of low, medium, and high variables were assumed for productivity, stumpage price, and expenses for each system. Current levels of revenues and expenses were assumed. An adjustment for an overall rate of inflation was incorporated into the calculations, but an increase by an assumed rate of inflation does not change LTEV because the nominal discount rate used, i, must also be adjusted for inflation, i.e., $i = r + f + r \times f$, where i = nominal discount rate, r = real discount rate, and f = overall rate of inflation.

The option for a linear and/or exponential real price increase for stumpage was incorporated. This real price increase does increase LTEV. The low set of assumptions was at the low end of the mean annual increment (MAI) range, low stumpage prices, and low expenses. The high set was at the high end for these variables. The MAIs assumed for all three systems were 518, 648, and 906 board feet per ha per year for low, medium, and high, respectively.

The DoF does not pay federal or state income, sales, or other taxes. However, it does make payments to the counties in which timber sales are made in lieu of tax. The payments are 15 percent of the net revenue from sales. The DoF records costs of labor for marking, paperwork, advertising, showing, access roads, and travel for each sale. Net revenue was assumed to be gross revenue minus an average direct cost of sales. The average cost of sales for the MMYC from 1994 to 2010 was about 8 percent (STDEV = 11.1) of the sales price.

Base Model: The base assumptions for the three silvicultural models were annual costs of $12.79, $25.59, and $38.38 per ha for the low, medium, and high levels. Linear real price increases for stumpage of $1, $2, and $3 per MBF were assumed. The average annual price increase for the trend line for real prices reported by Hoover and Preston (2011) is $2 per MBF. The discount rate used was 3 percent. The other base assumptions for the silvicultural model are presented in Tables 5, 6, and 7.

Table 5.—Even-aged volume harvested, unit price, and TSI expense.

	Low			Medium			High		
Year	Harvest (MBF per ha)	Value per MBF	TSI per ha	Harvest (MBF per ha)	Value per MBF	TSI per ha	Harvest (MBF per ha)	Value per MBF	TSI per ha
0	15.54	$300		20.72	$400		23.31	$500	
1			$259			$648			$1,036
2			$259			$518			$1,036
5			$518			$1,036			$1,554
10			$130			$130			$518
20			$130			$130			$518
30			$130			$130			$518
40	7.77	$150		10.36	$200		14.25	$250	
60	10.36	$200		12.95	$300		16.84	$400	
70				12.95	$350		16.84	$500	
80	23.31	$300		20.72	$400		24.61	$500	

Table 6.—Shelterwood volume harvested, unit price, and TSI expense.

	Low			Medium			High		
Year	Harvest (MBF per ha)	Value per MBF	TSI per ha	Harvest (MBF per ha)	Value per MBF	TSI per ha	Harvest (MBF per ha)	Value per MBF	TSI per ha
0	10.36	$350		15.54	$450		23.31	$550	
2			$518			$777			$1,036
5	2.59	$350		5.18	$450		5.18	$550	
15			$259			$259			$518
25			$259			$259			$518
35	2.59	$300		2.59	$350		5.18	$400	
65	7.77	$300		7.77	$350		14.25	$400	
80	18.13	$400		20.72	$450		24.61	$550	

Table 7.—Single tree selection volume harvested, unit price, and TSI expense.

	Low			Medium			High		
Year	Harvest (MBF per ha)	Value per MBF	TSI per ha	Harvest (MBF per ha)	Value per MBF	TSI per ha	Harvest (MBF per ha)	Value per MBF	TSI per ha
0	7.77	$300		10.36	$425		15.54	$500	
2			$130			$259			$518
15	6.48	$300		7.77	$425		12.95	$500	
17			$130			$259			$518
30	6.48	$325		7.77	$450		12.95	$550	
32			$130			$259			$518
45	5.18	$350		6.48	$500		7.77	$600	
47			$130			$259			$518
60	5.18	$350		6.48	$500		7.77	$600	
62			$130			$259			$518
70	5.18	$350		6.48	$500		7.77	$600	
72			$130			$259			$518
80	5.18	$350		2.5	$500		7.77	$600	

Results

The LEVs (LTEVs) ranged from -$13 per ha for the even-aged model with the low set of assumptions to $7,439 for the single-tree selection model with the high set of assumptions (Table 8). Revenue from the initial harvests for all three treatments was not included in NPV_0 and LTEV. The LTEVs with the initial harvest included can be calculated simply by adding the initial harvest values to the LTEV shown in Table 8. The differences between the low single-tree selection and even-aged LTEV can be interpreted to mean that application of even-aged silviculture reduces the value of forest land by $2,503 to $7,017 per ha. This reduction occurs because of the long waiting period for the intermediate and final harvests with even-aged management.

Table 8.—Land and timber expected values per hectare for base models.

Model	Low	Medium	High
Even-aged			
Initial harvest	$3,823	$6,179	$8,689
NPV_0	($12)	$8	$382
LEV	($13)	$9	$422
Shelterwood			
Initial harvest	$2,703	$5,213	$9,556
NPV_0	$935	$1,627	$2,933
LTEV	$1,032	$1,795	$3,237
Single-tree selection			
Initial harvest	$1,683	$3,282	$5,793
NPV_0	$2,256	$4,260	$6,740
LTEV	$2,490	$4,702	$7,439
Allowable cut			
LTEV	$4,107	$5,857	$7,608
LTEV including recreation	$4,930	$7,216	$9,502

The responsiveness of the models to changes in the specified variables was evaluated by comparing LEV (LTEV) for the base cases with the LEV (LTEV) for a change in one of the variables. The results are presented as elasticities, i.e., the percent change in LEV (LTEV) for a 1-percent change in one of the specified variables, *ceteris paribus* (Tables 9, 10, and 11). All variables except timber stand improvement (TSI) costs were elastic for the even-aged model. As expected, the only elastic variables in the two uneven-aged models were MAI and discount rate.

Table 9.—Sensitivity analysis for even-aged model. LISP = linear increase in stumpage price. EISP = exponential increase in stumpage price.

	Low	Medium	High
LISP	2.46	2.62	2.10
EISP	1.79	1.88	1.74
Discount rate	-10.35	-13.62	-10.03
MAI	8.49	10.34	12.39
Annual costs	-0.70	-0.94	-0.47
TSI costs	-5.74	-7.38	-3.02

Table 10.—Sensitivity analysis for shelterwood model. See Table 9 for abbreviations used.

	Low	Medium	High
LISP	0.18	0.24	0.33
EISP	0.81	0.67	0.93
Discount rate	-2.12	-1.59	-1.69
MAI	2.12	3.53	1.69
Annual costs	-0.14	-0.15	-0.12
TSI costs	-0.66	-0.56	-0.40

Table 11.—Sensitivity analysis for single-tree selection model. See Table 9 for abbreviations used.

	Low	Medium	High
LISP	0.10	0.22	0.19
EISP	0.37	0.46	0.45
Discount rate	-1.22	-1.26	-1.25
MAI	1.17	1.19	1.27
Annual costs	-0.06	-0.06	-0.10
TSI costs	-0.12	-0.12	-0.17

Capital Value Based on Allowable Cut

In addition to the per-hectare values for the three silvicultural treatments, an average value per hectare for the 6,772 ha of the MMYC under timber management was estimated using the current total allowable cut of 5,000 MBF per year assuming that 85 percent of the total area is available for timber production.[5] The capital values (LEV and LTEV) for the three silvicultural treatments should be used for making comparisons for alternative treatments for specific stands, or a mix of treatments to meet wildlife, recreational, and other values.

LTEVs based on the current allowable cut should consider the extent to which even-aged management is currently used. This consideration is important because a substantial shift to even-aged management would reduce the allowable cut in the immediate future. The application of even-aged management is indicated by the size of openings marked for sale over the last 18 years as shown in the detailed timber sale records. Two hundred twenty-three timber sales were conducted on the MMYC from 1993 through May 2010. Average tract size treated was 39.1 ha with timber harvested on 31.6 ha. The total area of openings marked averaged 1.9 ha per sale. Individual openings did not exceed 3.8 ha. Most of these were group-selection cuts. The price per MBF received for the 253 sales from January 1993 to May 2010 averaged $257.00 (STDEV $223.48) and ranged from $2,819.00 for a white oak veneer sale to $19.16 for a commercial TSI.

The average per-hectare capital value as measured by LTEV for the 6,772 ha under timber management was estimated for three sets of assumptions—low, medium and high. The annual harvest volume was 5,000 MBF for all three sets. The specified price received per MBF was $200, $280, and $360. A linear annual increase of $1, $2, and $3 per MBF was specified. An exponential real price increase of zero was specified for the base model. The specified annual management cost per hectare was $5.18, $10.36, and $15.54. Per-hectare LTEVs with annual recreation values of $10.00, $16.50, and $23.00 were estimated for the base model. The discount rate was 3 percent for all three sets. Per-hectare LTEVs obtained for the low, medium, and high models were $4,107, $5,857, and $7,608 respectively (Table 8). Inclusion of annual per-hectare recreation values of $10.00, $16.50, and $23.00 increased the base model LTEVs to $4,930, $7,216, and $9,502.

Sensitivity analyses were conducted by estimating elasticities for a doubling of the base model specifications *ceteris paribus* (Table 12) except for the discount rate. It was increased to 4 percent from the base model specification of 3 percent. Sensitivity to an exponential increase in price was evaluated for the change from 1-percent simple compound interest per year to 2 percent. Gross revenue was reduced by 8.07 percent for the cost of sales. Net revenue was reduced by 5 percent for the in-lieu tax payments to counties.

The increases in LTEV with an estimated value for recreation included were made assuming $24.00, $39.67, and $55.29 per ha per year for low, medium, and high models. The estimate for the medium set of assumptions was based on $41.29 per day-use visit (Table 1), 45 visits per weekend day, and 97 weekend days per year. These assumptions give a total of $180,850 per year and $11.11 per ha per year. This result was increased by $3.27 per ha per year for hunting and $25.19 for bird watching (Table 3). The latter value would account for hiking as most hikers engage in bird watching.

Table 12.—Sensitivity analysis for allowable cut model. See Table 9 for abbreviations used.

	Low	Medium	High
LISP	0.176	0.241	0.275
EISP	0.537	0.557	0.568
Discount rate	-0.454	-0.465	-0.470
Annual cost	-0.123	-0.174	-0.204
Recreation	0.212	0.237	0.251

[5] Personal communications with Jim Allen, MMYC property manager, 30 September 2011

SUMMARY

The MMYC exemplifies public forest land with stakeholders holding a wide range of management expectations. The need to be at least partially self-supporting financially, requiring sale of timber, adds a dimension similar to industrial forest land. Management strategies to meet the broad range of stakeholder expectations require the application of sound science appropriate for the MMYC. Information about how the forest is used and valued for non-timber purposes is also needed, especially in light of increased population density within typical day-use travel distances of the MMYC.

The information needed to evaluate tradeoffs between market and non-market values presents a particular challenge. Much of this challenge comes from a lack of information on the extent to which the MMYC is used for recreation, gathering of non-timber forest products, and scenic drives, and its role in defining the regional culture. Ongoing controversies about how the forest should be managed clearly indicate the significance of non-timber values among vocal stakeholders. The values held by a larger segment of stakeholders need to be quantified, but the results of the work by Rogers et al. (this publication) indicate a loss of non-market value when forest stocking in users' viewscapes is reduced.

Surveys of desired OR opportunities closely match those provided by the MMYC. Deer hunting is of particular significance. The mast crops of the oak-hickory forest type benefit the deer population, but data are lacking on the potential decline as the forest type moves toward maple-beech-birch. By extrapolation of the limited data available an estimated 400 to 500 deer are taken annually on the MMYC. The annual hunting value of the MMYC is in the range of $833,000. The wildlife viewing value is in the $2.3 million range per annum. The value of the lakes and ponds is in the range of $588,000 per annum. The total value is approximately $3.7 million, but multipliers for determining total economic impact are needed to make these values comparable to the estimated impact of timber revenue.

The gross annual economic impact of timber sales for the 17-year period from 1993 to 2010 averaged $94.9 million per annum (Table 4), assuming a gross economic multiplier of $51 per board foot (Hoover and Settle 2010). The fair market value of the MMYC as a unit is not relevant, but the capital value resulting from management for timber production can be used to estimate the opportunity cost of holding the land for timber production. The year-zero value of land managed in perpetuity for timber production under the even-aged, shelterwood, and single-tree selection systems ranged from $156 per ha for the even-aged model with the low set of assumptions to $8,590 for the single-tree selection model with the high set of assumptions (Table 8). These results can be interpreted to mean that application of even-aged silviculture reduces the value of forest land when used only for timber production from $7,770 to $2,590 per ha. Future analyses should add estimates of the reduction in recreational value when even-aged management is used.

Additional data collection and analyses are needed to develop non-timber value estimates comparable to the estimated economic impact of timber production.

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