

available at www.sciencedirect.comjournal homepage: www.elsevier.com/locate/envsci

Applying spatial analysis to forest policy evaluation: case study of the Illinois Forestry Development Act

Andrew D. Carver^{a,*}, Richard G. Thurau^b, Eric M. White^c, Marius Lazdinis^d

^a Department of Forestry, Southern Illinois University, Carbondale, IL 62901-4411, USA

^b School of Public and Environmental Affairs, Indiana University, 1315 East Tenth Street, Bloomington, IN 47405, USA

^c Department of Forestry, Michigan State University, 126 Natural Resources Building, East Lansing, MI 48824, USA

^d Faculty of Public Management, Law University of Lithuania, #310, Ateities 20, Vilnius, LT-08303, Lithuania

ARTICLE INFO

Keywords:

Forest policy

Forestry law

GIS

Economic incentives

ABSTRACT

Economic incentive programs are increasingly promoted in the United States and Europe as a method to encourage sustainable forest management practices on privately owned lands. This paper employs spatial analysis to evaluate the effectiveness of one such program created in Illinois through passage of the Illinois Forestry Development Act (IFDA). The Act establishes economic incentives available to private landowners who develop forest management plans and/or establish tree plantings. This paper provides (1) a description of the Illinois Forestry Development Act and its associated incentive program and (2) an evaluation of the program's land enrollments in respect to their potential for improving surface water quality. In order to evaluate the legislation in terms of water quality benefits, this paper develops a novel analytical approach utilizing a geographic information system (GIS) and high-resolution digital satellite imagery to locate and characterize land parcels enrolled in the IFDA landowner assistance program. The program has done well in enrolling lands located on steep slopes and has been moderately successful at enrolling lands within environmentally impaired watersheds. There is room for improvement in enrolling lands within the riparian areas of impaired waterways. However, the ability to enroll new lands in the program is limited by the program budget.

© 2006 Elsevier Ltd. All rights reserved.

1. Introduction

The implementation of sustainable forest development principles in Central and Eastern European countries during the last decade has involved a wide range of changes in forest policy and related administrative arrangements (Cirelli, 1999; Cirelli and Schmithüsen, 2000; Schmithüsen, 2000). As a result of the political and economic reforms of the 1990s, central and eastern European countries have largely adopted new forestry legislation. Similarly, though less drastic, changes in forest laws took place in western European countries as well. New

forestry legislation attempts to incorporate an increasingly diverse set of forest sector interests.

While principles of sustainable forest management have been embraced by these new legislative initiatives, concern exists over legal constraints that may serve to discourage private forestry activities (Mekouar and Castelein, 2002). In the context of sustainable forest development, when ecological, economic and social functions of forests must be balanced, strict regulation, control and enforcement are not necessarily the best options for facilitating sustainable private forest management. Currently, there is increasing awareness that

* Corresponding author. Tel.: +1 618 5491489; fax: +1 618 453 7475.

E-mail address: acarver@siu.edu (A.D. Carver).

1462-9011/\$ – see front matter © 2006 Elsevier Ltd. All rights reserved.

doi:10.1016/j.envsci.2006.01.002

the forest policy implementation process should better employ policy tools such as positive incentives and compensation. For example, [Doremus \(2003\)](#) suggested a policy portfolio approach to biodiversity protection on private land that stressed the importance of a range of policy options. In the case of the Czech Republic Forest Act, [Chytrý and Vasicek \(2002\)](#) called for positive incentives (i.e., financial support) to encourage a more balanced relationship between government support of forest management and restrictions imposed on forest owners. Another study by [Lazdinis et al. \(2003\)](#) showed that market intervention policy tools such as compensation and incentives are poorly used in the Baltic States. Therefore, it can be argued that presently there is a need to learn about mechanisms for practical implementation of the principles of sustainable forest development on privately owned land.

Through the examination of functioning incentive-based legislation, policymakers can better assess the likely impact that a new generation of incentive-based policies may have on forest management. The objectives of this study are twofold. First, a description of one such example of forest legislation from the midwestern United States is presented. Entitled the Illinois Forestry Development Act (IFDA), this state-enacted legislation is aimed at providing incentives for private landowners to manage their forests sustainably for both profit and public interest. The second objective of this study is to evaluate the IFDA's effectiveness at enrolling lands important for the enhancement of surface water quality. The conservation and reforestation of riparian areas and the reduction of marginal lands used for agricultural production is a focus of the IFDA landowner assistance (i.e., cost-share) program. In order to evaluate the legislation in terms of water quality benefits, this paper develops a novel analytical approach utilizing a geographic information system (GIS) and high-resolution digital satellite imagery to locate and characterize land parcels enrolled in the IFDA landowner assistance program.

1.1. Illinois Forestry Development Act

The Illinois Forestry Development Act (525 ILCS 15) was enacted in 1983 to provide financial and professional assistance for the conservation and expansion of privately owned forests in Illinois, with the objective of enhancing both the environmental and economic benefits associated with forest management. To date, 65,868 ha of land have been enrolled in IFDA programs across the state ([Bretthauer and Edgington, 2002](#)). To qualify for the IFDA land owner assistance program, a private landowner must develop a management plan for timber production on land that is at least 2 ha in size, at least 30.4 m wide, and void of any permanent buildings. Land enrolled in the program must remain in forest cover for a period of 10 years or until commercial harvest. The management plan must include a description of the land, the type of timber to be planted or managed, a harvest schedule, estimation of costs, soil and water conservation goals, wildlife habitat implications, and management practice descriptions. The plan must then be approved by the Illinois Department of Natural Resources (IDNR), which will assist in plan revisions.

Two categories of financial assistance are established by the Act and include property tax incentives and the cost-share program. With the passage of the IFDA, the Property Tax Code

(35 ILCS 200/10-150) was amended to provide a tax incentive for the Illinois forestland owner. In all counties with the exception of the densely populated Chicago metropolitan area, any privately owned land parcel being managed under a forest management plan approved under the guidelines of the IFDA is valued at 1/6 of its assessed value (which is based on crop productivity).

While property taxes are substantially reduced through IFDA enrollment, the cost-share program provides the most important incentives for private landowners to invest in forest management activities. The cost-share program reimburses participating landowners for a portion of their costs for activities which include the preparation of forest management and tree planting plans, reforestation, forest improvement practices, fencing to exclude livestock, firebreaks, and other management practices. Up to 75% of the costs can be reimbursed to the landowner ([IFDA, 1998](#)). Specific hourly rates for labor are specified as well as maximum payment amounts for planting, thinning, cutting, and other management activities. See [Fig. 1](#) for a summary of the silviculture, management, and reforestation cost-share provisions. Importantly, the Act specifies that the cost-share program is a reimbursement program and that advance payments are not possible.

Only a limited amount of funding for the cost-share program originates from the Illinois General Assembly (State government) appropriations made to the Illinois Department of Natural Resources. Rather, most funding is generated by the Act's authorization of the Illinois Forestry Development Fund through an amendment of the Timber Buyers Licensing Act (225 ILCS 732/2). This amendment requires that timber buyers deduct 4% of the purchase price for all timber sales and forward that amount along with a formal report to the IDNR. The Timber Buyers Licensing Act further requires that anyone buying timber must be licensed and bonded.

The IFDA is also designed to integrate with other State and Federal assistance programs to provide maximum financial support for private forest landowners. State-employed foresters within the IDNR coordinate activities with the United States Department of Agriculture Natural Resources Conservation Service, resulting in 80% of IFDA-enrolled lands also being enrolled in the Federal Conservation Reserve Program ([IFDC, 1999](#)).

1.2. Forest conservation and water quality

Water quality degradation induced by row crop farming practices is a common problem facing natural resource managers around the world. Agriculture is considered the major contributor to stream degradation in the United States, having adverse effects on in-stream habitats and water quality ([USEPA, 1994](#)). Nutrient loadings and sediment deposition have been identified as the water quality problems of greatest concern ([Chesters and Schierow, 1985](#)). An agriculturally impacted stream may undergo a number of changes in its structure, chemistry and in-stream habitat. Some of these changes include, but are not limited to, changes in stream morphology, sedimentation and increased nutrient levels.

Throughout the midwestern United States, agriculture is currently the predominant land use. Within Illinois, only 11% of lands forested prior to European settlement are currently

- FDA Cost-share Program
 - Plan Preparation
 - Forest management plans – up to \$17/ha
 - Tree planting plans – up to \$10/ ha
 - Plans must be approved by District Forester
 - Tree Planting
 - 1075 minimum number of trees per hectare
 - The average spacing is about 3m x 3m
 - Cost share up to \$235/ha for State-grown trees (provided free) or up to \$692/ha for purchased trees
 - Timber Stand Improvement
 - Option to use cut trees for firewood & wildlife habitat
 - Cost share up to \$111/ha
 - Pruning
 - Best trees are pruned to at least 5m
 - Cost share up to \$125/ha
 - Reducing Wildlife Damage
 - Tree shelters – up to \$370/ha
 - Electric fencing – up to \$1.25/meter
 - Repellents – up to \$37/ha
 - Bud protectors - \$12/ha
 - Site Preparation for Natural Regeneration
 - Light disking, cutting, herbicides, burning
 - Cost share limits from \$74 to \$445/ha

Fig. 1 – Incentives (US\$) provided through the Illinois Forestry Development Act (IFDA) landowner assistance program.

forested and the most rapid conversion of forestland to agricultural production is occurring on bottomland sites near streams and rivers (IFDC, 1999). This trend is expected to continue as farmers own 45.5% of all commercial forestland in Illinois (IFDC, 1999). Of Illinois' 4.3 million acres currently under forest vegetation, 1.6 million acres (37 %) are sites with soil classes suitable for agricultural production (IILCP, 2002).

Over the past two decades, studies have been conducted to determine the amount of nutrients and sediment lost in runoff, and how these nonpoint source pollutants can be minimized (Lowrance et al., 1983; Peterjohn and Correll, 1984; Pinay and Decamps, 1988; Muscutt et al., 1993; Edwards et al., 1996). One tool that has become widely accepted as a defense against excess nutrients and sedimentation is the use of vegetated riparian buffer zones.

The Illinois Forestry Development Council (IFDC, 1999) emphasizes minimizing disturbance of vegetative cover adjacent to waterways (particularly on slopes) as the best approach to protecting surface water quality and reducing erosion. To qualify for IFDA assistance, management plans must emphasize forest buffers along waterways (IFDC, 1999). The IFDC (1999) suggested that along with the conservation of current forests, the reestablishment of forests in riparian areas is crucial to ensuring the health and quality of fishery habitat in Illinois.

A forested riparian zone can effectively filter lateral overland flow when it enters the buffer as sheet flow draining from a small field with minimal slope (Peterjohn and Correll, 1984). In addition, several studies have shown that riparian zones can decrease the nutrient levels of groundwater

entering the stream (Jacobs and Gilliam, 1985; Cooper, 1990; Haycock and Pinay, 1993; Jordan et al., 1993). The effectiveness of these forested riparian buffers at the field scale has been well documented (Groffman et al., 1991; Haycock and Pinay, 1993; Addy, 1999). However, Herron and Hairsine (1998) suggested that land management initiatives need to be directed at the catchment as a whole if riparian buffers are to be effective tools in reducing nonpoint source pollutants.

2. Methodology

2.1. Study area

In order to determine the effectiveness of the IFDA in enrolling lands with the greatest potential for enhancing water quality, this catchment-level analysis examines a two-county region in southern Illinois. Consisting of Pope and Hardin Counties, the study area encompasses 143,470 ha (Fig. 2). The study area was chosen because the region has been targeted for water quality improvement by both the Illinois Environmental Protection Agency (IEPA) and the IDNR. Additionally, the soils and vegetation are similar to other geographic regions in Illinois that suffer from nonpoint source pollution and its negative impacts on water quality.

While cropland and pasture account for more than 44,000 ha (31%) of the study area, forests predominate. Public and privately owned forests cover approximately 84,000 ha (59%) of the study area. Composed primarily of deciduous hardwood species, forests within the study area are classified

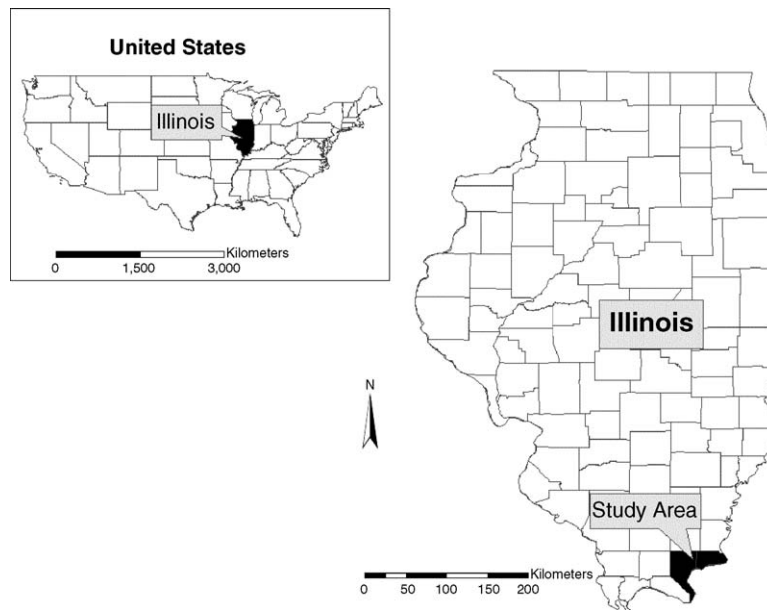


Fig. 2 – The study area consists of Pope County and Hardin County in Illinois, U.S.A.

as Western Mesophytic, consisting mainly of the oak-hickory forest type on drier sites and maple-beech forests on moist sites (Fralish et al., 2002; Braun, 1950). There is a minor component of eastern redcedar (*Juniperus virginiana*) scattered across the forest and an even smaller amount of natural shortleaf pine (*Pinus echinata*) restricted to the higher elevations. Plantations of shortleaf pine, however, are common throughout the study area. These plantations were established in the 1930s to stabilize the soil of abandoned upland fields and are now publicly owned as part of the Shawnee National Forest.

Average slope in the study area is approximately 10% with a range from 0% to 120% (USGS, 1997). Upland soils are dominated by Alfisols with a wind-deposited loess cap covering the area. Soil texture is typically silt loam at the surface (A horizon) to silty clay loam or clay loam (B horizon).

2.2. Procedure

In addition to outlining the provisions of the IFDA, the objective of this study is to evaluate the IFDA's effectiveness at enrolling land areas important for the enhancement of surface water quality. The approach consists of two procedural components that utilize a geographic information system (GIS) and high-resolution digital satellite imagery. The first procedure consists of the creation of a geo-referenced database that identifies the tracts of land that are either eligible for or currently enrolled in the IFDA landowner assistance program. The second procedure characterizes IFDA-enrolled lands based on their potential contribution to water quality protection. Three location-dependent land characteristics are examined in detail and include slope class of enrolled land, location of enrolled land within watersheds experiencing high levels of nonpoint-source pollution, and location of enrolled land within important riparian buffer zones.

2.3. Data layer development

The geo-spatial database of IFDA lands developed for this study represents Illinois' first digital database of lands enrolled in the IFDA landowner assistance program. Legal land descriptions and county plat maps were initially employed by the Illinois Farm Service to produce paper maps of the study area showing the property ownership boundaries for private landowners who were participating in the IFDA cost-share program. These paper maps were then assembled along with recorded management plans and aerial photographs to aid in the creation of a digitized map layer depicting the spatial distribution of IFDA-enrolled lands within the study area. Digitizing was performed on-screen using ArcGIS 8.2 (ESRI, 2002). The base map over which the digitizing was performed consisted of gray-scale satellite ortho-imagery (DOQQs) at a resolution of 1 m × 1 m. Enrolled lands included both currently forested stands and lands recently planted in trees under the Act's cost-share program. Additional data layers used or developed for this study include land use data, topography data and water quality data. Each data layer is described below.

The slope data layer was derived from a digital elevation model (DEM) produced by the United States Geological Survey at 1:250,000 scale (USGS, 1997). Slope was calculated from the DEM using surface analysis in ArcGIS 8.2 (ESRI, 2002) at 30 m × 30 m pixel resolution. Slope was then classified into four categories: 0–2%, 2.1–5%, 5.1–10%, and greater than 10%.

Land cover data were created by the Illinois Interagency Landscape Classification Project (IILCP, 2002), in collaboration with the United States Department of Agriculture (USDA) and the IDNR. The land cover data were comprised of 23 classifications detailing agricultural, industrial, residential and natural land cover at 30 by 30 m pixel resolution. For this study, land cover classifications listed as "agricultural land" (classes 11–17) were combined to represent agricultural land

use. Likewise, land cover classifications listed as “forested land” (21–26) and “floodplain forest” (43) were combined to represent forest cover.

Water quality-related maps layers provide the location of waterways and associated watersheds within the study area that did not meet national water quality standards. Specifically, the IEPA is mandated by the Federal Water Pollution Control Act (33 U.S.C. 1251) to publish an annual report evaluating the quality of waters inside the State of Illinois. Section 305(b) of the Illinois Water Quality Report (IEPA, 2002) assesses waterways and water bodies in Illinois to determine the level of compatibility with each water segment’s designated use category. The IEPA designates a water segment as “impaired” if the segment partially or completely fails in compatibility with its designated use. Impaired water segments are then identified by law as having water quality limited waters (WQLWs). This study utilizes geo-spatial databases produced by the IEPA (1996) to identify all impaired waterways (i.e., streams and rivers) and impaired watersheds (i.e., subwatersheds that drain into impaired waterways). A GIS map layer identifying riparian zones adjacent to impaired waterways (lands within 30 m from each stream bank) was also derived from the IEPA geo-spatial database.

3. Results

The first procedural component of this study consisted of the creation of a geo-referenced database that identifies the tracts of land that are either eligible for or currently enrolled in the IFDA landowner assistance program. Of the 143,470 ha study area, 91,731 ha (64%) of privately-owned lands are eligible for enrollment in the IFDA landowner assistance program. Ineligible lands included areas owned by the Federal and State governments (e.g., the Shawnee National Forest and the Illinois State Parks System) as well as private and public lands within municipal or town boundaries. Of all eligible lands, 5277 ha (6%) are currently enrolled in the IFDA program.

A total of 670 individual land parcels are enrolled in the IFDA landowner assistance program in Pope and Hardin Counties. Two hundred one of these parcels consisted of agricultural land that was planted with trees through IFDA assistance. Tree plantings accounted for 18% (969 ha) of all IFDA lands in Pope and Hardin Counties, with a mean tract size of 4.8 ha. Enrolled lands consisting of existing forest cover totaled 4308 ha (82%) with a mean size of 9.3 ha. Graphical results of the digitizing procedure are shown in Fig. 3. IFDA-enrolled lands (in black) are overlaid on a map of sub-watershed boundaries. Sub-watersheds shaded gray are classified by the IEPA as “impaired” since they drain into waterways experiencing high levels of nonpoint source pollution.

The second procedural component employed geo-spatial analysis to characterize IFDA-enrolled lands based on their potential contribution to water quality protection. Three location-dependent land characteristics were examined in detail, including (1) slope class of enrolled land, (2) extent of land enrollment within impaired watersheds experiencing high levels of non-point source pollution, and (3) extent of land

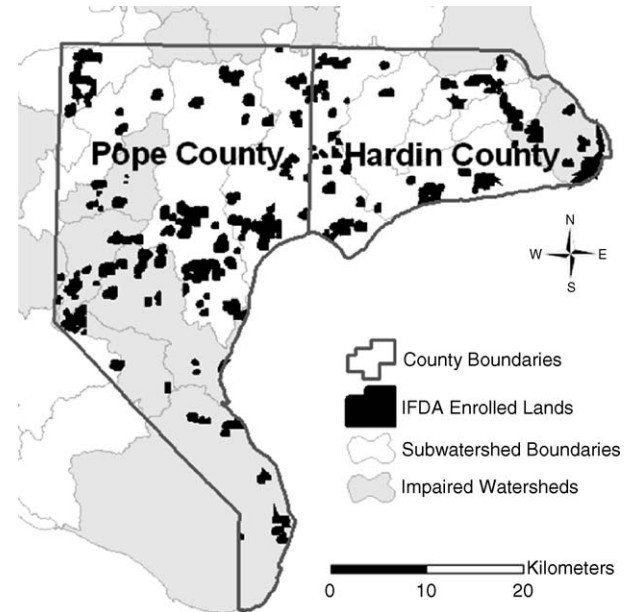


Fig. 3 – Spatial distribution of lands enrolled in the IFDA landowner assistance program (in black). Water quality impaired watersheds appear shaded in gray.

enrollment within a 60 m riparian buffer of impaired river and stream segments.

3.1. Slope class of enrolled land

In this study, slope was utilized as a proxy measure for the erodibility of land within the study area. Results indicate that 4833 ha (nearly 73%) of all IFDA enrolled lands are characterized by highly erodible slopes of greater than 5%. Only 652 ha of the much less erodible, nearly level slope class of 0–2% has been enrolled. Fig. 4 shows the distribution of slope classes for enrolled lands within the study area.

While there is little doubt that the enrollment of erodible slopes is an important factor for improving surface water quality, the location of these enrolled lands may be an even more important factor. For example, enrolling highly erodible land within impaired watersheds could have greater water quality impacts than enrolling similar lands within watersheds that are not experiencing high levels of sedimentation

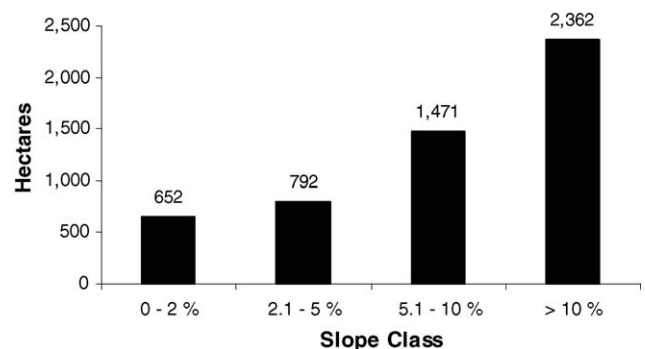


Fig. 4 – Distribution of slope classes for enrolled lands within the study area.

and agricultural runoff. Furthermore, the formation of riparian buffers through the enrollment of lands adjacent to impaired streams could perhaps yield the greatest water quality benefit.

3.2. Enrolled land within impaired watersheds

The study area contains portions of 10 impaired watersheds (IEPA, 2003), consisting of more than 51,000 ha. Eligible lands within these impaired watersheds totaled more than 35,730 ha, with 7617 ha in agricultural use and 12,323 ha of forest. Eligible lands within the impaired watershed comprise 39% of the total eligible lands in the study area. More than half of the impaired watershed eligible lands have slopes of greater than 5%. Given these steep slopes, forest management plans and the conversion of agricultural land to forests, facilitated through the IFDA program, may yield significant improvement in water quality.

Unfortunately, these impaired watersheds contained only 1627 ha of enrolled land, representing only 5 % of eligible lands within impaired watersheds. Importantly, however, these 1627 ha represent 31% of all enrolled lands in the study area (Fig. 5). Given this level, it appears that the IDNR is enrolling a fairly proportional number of impaired watershed hectares. However, an increase in the proportion of hectares enrolled within the impaired watersheds may have a positive impact on water quality within the study area.

3.3. Enrolled land within riparian buffers

Those lands in immediate proximity to impaired rivers and streams may be the most critical for conservation actions aimed at improving water quality. Establishment and conservation of riparian forest are stated objectives of the IFDA program. To evaluate how well the IFDA has succeeded in conserving these riparian areas, the enrollment of lands adjacent to impaired waterways within the study area was examined more closely.

IFDA eligibility and enrollment within 30 m of each side of the study area's five impaired waterways were identified using the GIS. In total, 1259 ha in the riparian areas were eligible for enrollment in the IFDA program. Unfortunately, only 44 ha of riparian land were found to be enrolled in the IFDA program, representing 3.5% of the eligible riparian land. These enrolled riparian lands also represent only 0.8% of IFDA lands in the entire study area (Fig. 5). Given the high conservation value that riparian areas may offer, the benefits of enrolling a greater

percentage of the eligible land area may be quite large. As such, greater emphasis on enrolling riparian lands in IFDA may be appropriate.

4. Conclusions

The Illinois Forestry Development Act is an example of voluntary, incentive based forest legislation aimed at improving the participation of private landowners in sustainable forest management. Evaluating the effectiveness of such a policy and its implemented programs is often difficult given the spatially dependent, landscape-level impacts of resulting land use change. This study utilized GIS technology and spatial analysis to overcome such difficulties and enhance the policy evaluation process.

There is little doubt that improvements have been realized from the IFDA enrollment of thousands of hectares across Illinois. However, results of this study show that environmentally sensitive areas are being targeted only to a limited extent. Though a total of 5277 ha were enrolled in the two-county study area, only 44 ha of water quality impaired riparian buffer strips and 1627 ha of land within impaired watersheds have been enrolled in the first 15 years of the program.

Unfortunately, program funding is severely limiting opportunities for program expansion. The funding constraints are evident by a typical waiting period of one year for program applicants to receive assistance with plan development from a state-employed forester. At present, no additional funding mechanisms are under consideration.

Negative impacts of funding constraints may be minimized through effective targeting of lands in greatest need of reforestation and conservation. While only 6% of all eligible lands within the study area are currently enrolled, a favorably disproportionate 31% of enrolled lands are located within impaired watersheds. Improvement may be most needed within the 60 m buffer of impaired waterways where only 0.8% of currently enrolled lands are located.

When examining the effectiveness of the IFDA at targeting lands with the greatest threat for sedimentation and runoff (i.e., steepest slopes), success can be argued with 45% of all enrolled lands having a slope of 10% or greater. This is further evident in examining IFDA enrollment within impaired watersheds (where 37% of enrolled lands have slopes of 10% or greater), and land adjacent to impaired waterways (where 32% of enrolled riparian lands have slope of 10% or greater).

While European countries with economies in transition are experiencing increased private ownership of timber resources, the United States is shifting its timber procurement from the publicly owned forests of the western U.S. to the largely privately owned forests in the Midwest and Southeast. These trends signal a significant income opportunity for private forest landowners in Europe and the United States. Those landowners with propensity to manage and harvest timber will have the greatest chance of benefiting from increased demand or reliance for privately owned timber. Yet, private forest ownership presents challenges for environmental protection. The Illinois Forestry Development Act was enacted to enhance the development of forest industry in the State of Illinois through the provision of financial incentives that

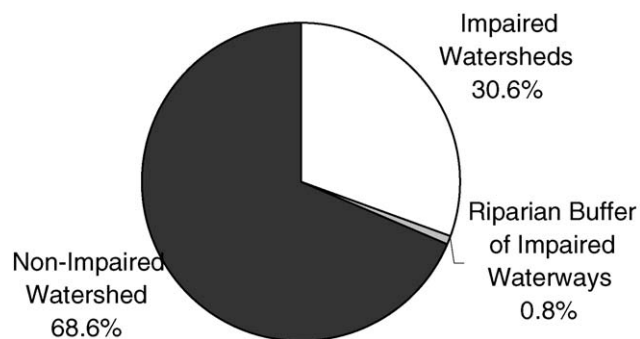


Fig. 5 – Location of FDA enrollments within the study area.

encourage landowners to produce timber in a sustainable manner, consistent with broader societal and environmental goals. Though the need for improvement can be argued, the Illinois Forestry Development Act and its funding mechanism represent an example of how sustainable forest development can be facilitated by using positive incentives in the implementation of forest policy.

Acknowledgements

This study benefited greatly from the support of the Illinois Department of Natural Resources and David Allen, Region 21 District Forester.

REFERENCES

- Addy, K.L., 1999. Ground water nitrate removal in subsoil of forested and mowed riparian buffer zones. *J. Environ. Quality* 28, 962–970.
- Braun, E.L., 1950. *Deciduous Forests of Eastern North America*. Blakiston, Philadelphia, PA, 596 pp.
- Bretthauer, S., Edgington, J., 2002. *Forest Resources of Illinois: 2002*. Department of Natural Resources and Environmental Sciences. University of Illinois, pp. 88.
- Chesters, G., Schierow, L., 1985. A primer on nonpoint source pollution. *J. Soil Water Conserv.* 40 (1), 9–13.
- Chytrý, M., Vasicek, J., 2002. Forest Act in the Czech Republic. In: F. Schmithüsen, G. Iselin, and D. LeMaster (Eds.), *Experiences with New Forest and Environmental Laws in European Countries with Economies in Transition*. Proceedings of the 3rd International Symposium, Jundola Bulgaria, June 2001. Zurich, 2002.
- Cirelli, M.T., 1999. Trends in Forestry Legislation: Central and Eastern Europe. *FAO Legal Papers Online*, No. 2. Accessed September 10, 2000. Available from <http://www.fao.org/Legal/default.htm>.
- Cirelli, M.T., Schmithüsen, F., 2000. Trends in Forestry Legislation: Western Europe. *FAO Legal Papers Online*, No. 10. Accessed September 10, 2000. Available from <http://www.fao.org/Legal/default.htm>.
- Cooper, A.B., 1990. Nitrate depletion in the riparian zone and stream channel of a small headwater catchment. *Hydrobiologia* 202, 13–26.
- Doremus, H., 2003. A policy approach to biodiversity protection on private lands. *Environ. Sci. Policy* 6, 217–232.
- Edwards, D.R., Moore Jr., P.A., Daniel, T.C., 1996. Grassed filter strips can reduce losses of nitrogen and phosphorous in runoff. *Better Crops* 80 (4), 8–11.
- Environmental Systems Research Institute, Inc. 2002. *ArcGIS 8.2*. Environmental Systems Research Institute, Inc. Redlands, CA.
- Fralish, J.S., Carver, A.D., Anderson, R.C., Ruffner, C.M., Thurau, R.G., Sauer, S.L., Close, D.D., Swigart, R., White, E.M., 2002. *Presettlement, present, and projected forest communities of the Shawnee National Forest*. Final Report, United States Department of Agriculture Forest Service Agreement No. 00-CS-11090804-011. pp. 133.
- Groffman, P.M., Axelrod, E.A., Lemunyon, J.L., Sullivan, W.M., 1991. Denitrification in grass and forest vegetated filter strips. *J. Environ. Quality* 20, 671–674.
- Haycock, N.E., Pinay, G., 1993. Groundwater nitrate dynamics in grass and poplar vegetated riparian buffer strips during winter. *J. Environ. Quality* 22, 273–278.
- Herron, N.F., Hairsine, P.B., 1998. A scheme for evaluating the effectiveness of riparian zones in reducing overland flow to streams. *Aust. J. Soil Resources* 36, 683–698.
- Illinois Environmental Protection Agency. 1996. *Watersheds 14-Didgits HUC*. Illinois State Water Survey. Available online at: <http://maps.epa.state.il.us/website/wqinfo/metadata/wshed14.htm>.
- Illinois Environmental Protection Agency. 2002. *Illinois Water Quality Report 2002 Section 305(b) Report*.
- Illinois Environmental Protection Agency. 2003. *Illinois 2002 Section 303 (d) List*. IEPA/BOW/03-016. Bureau of Water, Post Office Box 19276, Springfield, Illinois 62794-9276. Available online at: <http://www.epa.state.il.us/water/watershed/reports/303d-report/2002-report/303d-report-2002.pdf>.
- Illinois Forestry Development Act. 1998. Part 1536 – Forestry Development Cost-Share Program. Source: Amended at 22 Ill. Reg. 10473, effective June 1, 1998.
- Illinois Forestry Development Council, 1999. *Realizing the Forests' Full Potential: Assessment and Long-Range Action Plan for Forest Resources in Illinois*. Prepared by the Illinois Forestry Development Council, University of Illinois, W503 Turner Hall, 1102 South Goodwin Avenue, Urbana, IL 61801.
- Illinois Interagency Landscape Classification Project, 2002. *Land Cover of Illinois 1999–2000*. Available online at: <http://www.agr.state.il.us/gis/landcover99-00.html#ref>.
- Jacobs, T.C., Gilliam, J.W., 1985. Headwater stream losses of nitrogen from two coastal plain watersheds. *J. Environ. Quality* 14 (4), 467–472.
- Jordan, T.E., Correll, D.L., Weller, D.E., 1993. Nutrient interception by a riparian forest receiving inputs from adjacent cropland. *J. Environ. Quality* 22, 467–473.
- Lazdinis, M., Tõnisson, K., Silamikele, I., Carver, A., 2003. Innovative use of forest policy instruments in countries with economies in transition: experience of the Baltic states. In: Schmithüsen, F.; Iselin, G.; Herbst, P. (Eds.), *Forest Law and Environmental Legislation – Contributions of the IUFRO Research Group 6.13 – Proceedings VIII*. Forest Science Contributions, Chair Forest Policy and Economics; Swiss Federal Institute of Technology, Zurich.
- Lowrance, R.R., Todd, R., Asmussen, L.E., 1983. Waterborne nutrients budgets for the riparian zone of an agricultural watershed. *Agric. Ecosyst. Environ.* 10, 371–384.
- Mekouar, A., Castelein, A., 2002. Forestry legislation in Central and Eastern Europe: A comparative outlook. In: Schmithüsen, F., Iselin, G., LeMaster, D. (Eds.), *Experiences with New Forest and Environmental Laws in European Countries with Economies in Transition*. Proceedings of the Third International Symposium, Jundola Bulgaria, June 2001, Zurich.
- Muscutt, A.D., Harris, G.L., Bailey, S.W., Davies, D.B., 1993. Buffer Zones to improve water quality: a review of their potential use in UK agriculture. *Agric. Ecosyst. Environ.* 45, 59–77.
- Peterjohn, W.T., Correll, D.L., 1984. Nutrient dynamics in an agricultural watershed: Observations on the role of a riparian forest. *Ecology* 65, 1466–1475.
- Pinay, G., Decamps, H., 1988. The role of riparian woods in regulating nitrogen fluxes between the alluvial aquifer and surface water: a conceptual model. *Regulated Rivers* 2, 216–507.
- Schmithüsen, F. 2000. The expanding framework of law and public policies governing sustainable uses and management in European forests. In: F. Schmithüsen, F., Herbst, P., Le Master, D. (Eds.), *IUFRO World Series Volume 10 – Forging a New Framework for Sustainable Forestry: Recent Developments in European Forest Law*, 1–27. Zurich: IUFRO Secretariat Vienna, Chair Forest Policy and Forest Economics, ETH.

United States Environmental Protection Agency, 1994. The quality of our nation's water: 1992. EPA 841-s-94-002.

United States Geological Survey, 1997. 1:250,000-scale Digital Elevation Models for Illinois. Available online at: http://edcsgs9.cr.usgs.gov/glis/hyper/guide/1_dgr_demfig/states/IL.html.

Andrew D. Carver is Associate Professor of Forestry at Southern Illinois University and Visiting Scientist at the U.S. Forest Service International Institute of Tropical Forestry. Dr. Carver specializes in theoretical and applied mathematical modeling of environmental systems and human-environmental interactions. Most recently his research program has focused on the role of natural resources and ecosystems in sustainable development and protected areas management in the neotropics.

Richard G. Thureau is a Doctoral Graduate Research Assistant and Instructor at Indiana University's School of Public and Environmental Affairs. He teaches and conducts research in landscape-level spatial analysis and environmental planning.

Eric M. White was a Doctoral Graduate Research Assistant at Michigan State University at the time of this research and writing. He has a PhD from Michigan State University and conducts research in the areas of natural resource economics and policy.

Marius Lazdinis is Vice Dean, Faculty of Public Management, Law University of Lithuania. Dr. Lazdinis holds a PhD from Southern Illinois University and specializes in forest and environmental policy analysis as well as forestry development in transition economies.