# DEVELOPMENT OF LANDSAT DERIVED FOREST COVER INFORMATION FOR INTEGRATION INTO ADIRONDACK PARK GIS

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Based upon observed changes in timber harvest practices partially attributable to forest biomass removable for energy supply purposes, the Adirondack Park Agency began in 1979 a multi-year project to implement a digital Geographic Information System (GIS). An initial developmental task was an inventory of forest cover information and analysis of forest resource change and availability. While developing the GIS, the Agency, with consultant assistance, undertook a pilot project to evaluate the usefulness of Landsat derived land cover information for this purpose, and to explore the integration of Landsat data into the GIS.

The prototype Landsat analysis project involved 1) the use of both recent and historic data to derive land cover information for two dates; and 2) comparison of land cover over time to determine quantitative and geographic changes. The "recent data," 1978 full foliage data over portions of four Landsat scenes, was classified, using ground truth derived training samples in various forested and non-forested categories. This inventory resulted in the classification of 83 percent forested and 17 percent non-forested, as generalized by combining categories. Forested categories include the following: northern hardwoods, pine, spruce-fir, and pine plantation, while non-forested categories include wet-conifer, pasture, grassland, urban, exposed soil, agriculture, and water.

Similarly classified "baseline" data (1972 leaf-off data) were found to be generally incompatible with the "recent" classification because of an overestimate of non-forested areas. A conservative interim estimate of forest cover loss over the period was, however, derived by narrowing the evaluation to one classifier which detected in the "recent" data forest areas subject to cover loss due to harvest, pests or blowdown. Areas classified by this signature were compared to the baseline data, to determine whether or not they were forested in 1972, using a 9 pixel search window.

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Lower quality, but full foliage, baseline data is currently being processed to provide a more comprehensive analysis of forest cover infill as well as loss.

The 1978 landcover information has been integrated into the Agency's GIS as one of three study area complete data sets. Digital geographic data is stored in raster format on a one acre grid cell structure keyed to the New York State Universal Transverse Mercator grid. Data is digitized and processed using a turn key packaged micro-processor system purchased by the Agency. Using the GIS, land cover data for selected munici- palities has been combined with other variables and used to measure development proximity to "critical natural sites", predict recreational use potential, and estimate the regulatory protection afforded forest and open space resources by Agency planning. New digital data sets for soils, elevation, public infrastructure, economic and demographic data are planned for 1982-84 addition to the GIS. These will expand the potential for forest cover analysis by adding site considerations, either by providing a weighted variable in the Landsat image processing stage of analysis, or in geographic comparisons of raster data sets using other GIS capabilities.

# INTRODUCTION

## Agency Role in Adirondack Park

The NYS Adirondack Park is an area of approximately 9300 square miles in northern New York. It is composed of intermingled large state and private landholdings with scattered small settlements ranging in size to about 7,000 residents. About one-third of the land is state-owned. Virtually all state-owned land is removed by state constitutional rule from timber harvesting.

Large private landholdings are held by relatively few landowners. About 50% of the private land is in holdings greater than 1000 acres in area. The bulk of this land is devoted to forest management by industrial landowners. Some is held in private preserve status which may also be managed for timber and biomass production.

The Adirondack Park Agency is an Agency of the NYS Executive Department with regional responsibilities for planning and regulation of new private land-use and development. A sister agency, the NYS Department of Environmental Conservation, is responsible for the care and custody of most state-owned lands and state-wide environmental regulations. The New York State Energy Office supervises preparation and implementation of the "New York State Energy Master Plan II," now in its second iteration. The Park Agency works closely with other state agencies for differing objectives such as the development of the State Energy Master Plan, the policy document that guides all state agencies with respect to state energy policy (1).

## Reasons for interest in landcover information

The Adirondack Park Agency has sought techniques to rapidly assess natural resources park-wide and to track stress and significant changes over time. Primary short-term concerns of the Agency relate to responsibilities for permit issuance for new land use and development, and therefore to human or development-caused changes. Most clearcutting and shoreline cutting requires permits from the Agency. Other timber harvesting does not. Longer range Park policy concerns include forest diseases and acid precipitation, albeit in conjunction with other state agencies that have principal responsibility for such issues state-wide, especially the Department of Environmental Conservation.

Both the managed forests and the Forest Preserve (the reserved state lands) are subject to a variety of forest disease problems such as scleroderris in red pine, beech bark disease, and others. These problems diminish the attractiveness of infested stands for traditional markets, and have further stimulated interest in biomass market for energy. With a market for low-grade material timber stand improvement could become more economically attractive (2).

The assessment of public and private forests for real property taxation has become an issue as fiscal constraint and court-mandated changes in assessment procedures are reflected in the property tax system. Upward pressure on forest land real tax burden is reflected by tax increases in some towns in the Park on the order of 100-150 percent (3).

Private forests, at least prior to the current economic recession, have also been subject to increasing cutting pressure for home fuelwood, and conventional pulp wood production (4).

Interest in Adirondack biomass resources reached one peak with the proposal by the City of Burlington, Vermont to rely on wood-fueled electric power generation for a significant portion of its electric energy supply. The Burlington proposal is based in part on a smaller-scale experimental program that utilized as one source of fuel green-wood chips produced for the city as a by-product of an operation feeding wood-chip biomass from the Northern Adirondacks to a paper mill in Cornwall, Ontario (5).

The Burlington proposal has since been changed to rely heavily on rail transport of chips, a factor which will significantly limit the supply that could be shipped from the Adirondack Park given its existing rail network.

The State Energy Plan documentation also reveals a number of northern Adirondack biomass energy proposals, some of which go beyond the experimental stage. Clarkson College in Potsdam, New York has adapted a major boiler facility for green-wood chips (6).

One proposal for an experimental wood-fired electricity and steam generation plant in Tupper Lake, New York failed to make the grade with grant reviewers, apparently because of a lack of market for cogenerated steam and uncertainty about the availability of local low-grade biomass (7).

Thus, the shift to biomass energy within the Adirondack Park appears limited to its use as home fuelwood for the near future. A change in general economic conditions could, however, unleash general demand for the wood biomass resources of the region, leading to consequences that are significant for the Adirondack Park policies guided by the Adirondack Park Agency. Under assumptions of good forest management, this could lead to general improvements in productivity and profitability of a major industry in the region over the long term. Less optimistic seers worry about large-scale clearcutting and associated problems for regeneration of valuable forest stands, site specific environmental disruption and dependence on chemical treatments to deal with nutrient losses or protection of planted species from pests or competing vegetation.

The Agency examined these questions at some length in 1980 and 1981, resulting in several special reports summarized in a

publication "Clearcutting in the Adirondack Park", a report of the Joint Government-Industry Steering Committee on Intensive Timber Harvesting in the Adirondack Park to the Adirondack Park Agency, May, 1981 (8).

The Agency's policy concerns were complicated by lack of year-by-year data that correlated well with the 1968 or 1980 USFS surveys of standing timber supply. Accurate projections of growth and removals as they might be influenced by biomass removals have not progressed beyond forecasts of available supply (9). Stocking information is dated or lacking for the region except for some areas of industrial holdings where the information is considered proprietary.

The Agency commissioned a preliminary analysis using computer projection techniques from 1968 data along with phone survey and NYS Department of Environmental Conservation product removal information (10). This showed significant drains on hardwoods, but has proved difficult to reconcile with 1980 USFS survey data because of uncertainty about fuelwood biomass harvest and inherent difficulties in projecting forward from the USFS inventory data. Preliminary 1980 survey statistics suggest that the computer projection under estimated available inventory (11).

At the same time in 1981 the Agency made final commitments to a computerized Geographic Information System (GIS). The GIS as a first priority is intended to extend and document McHargian overlay analysis of development constraints within the Park adding economic and demographic factors to allow a fuller documentation of the Adirondack Park Land Use and Development Plan, a regulatory plan aimed at new land use and development of regional significance within the Park (12).

The GIS system for the Park was assembled in a configuration that would also permit direct Landsat image processing, both with the NASA Landsat satellites and the upcoming Landsat D technology. While this is of interest to the McHargian development capability analysis, it is of primary interest because of the ability to track larger-scale resource changes on a park-wide basis.

The concern for biomass removals and the Agency's legal requirement for a permit for clearcutting as defined in the Adirondack Park Agency Act, caused the first applications of the Landsat change analysis techniques to be made to determine forest cover change. Similar legal responsibilities address wetlands, and the dynamics of the wetlands systems of the Park are of equal ecological significance, but have been deferred to the completion of a remapping of the wetlands in the Park to 1 acre size thresholds (state-wide mapping uses approximately 12 acre thresholds) (13).

The prototype Landsat analyses addressing biomass availability and clearcutting are described in the following sections of this paper.

## LANDSAT LANDCOVER ANALYSIS

The Agency's first goals with regard to the use of Landsat data were to investigate the usefulness of these data in the varied land use planning analyses needed by the Agency. Reliability, cost effectiveness, timeliness of coverage, labor required and ease of access are limitations associated with conventional photo interpretation. Landsat promised to reduce the cost of rectification of these liabilities through digital analysis.

To address the issues of biomass availability and forest cover change, the prototype Landsat analysis would seek to produce a classification of recent data, including classification of signatures for cut forest land, for areas of new construction or disturbed soil, for forested land, wetlands and developed or open areas. In addition to examining the potential for determining areas with changing landcover by their characteristic signature, a temporal change analysis was to be undertaken to compare current landcover data to past conditions. The temporal analysis would permit an estimation of forest infill as well as loss. Underlying these expectations was the need to produce a relatively simple classification, in a cost effective manner, which could be duplicated at the end of another period in order to continue to monitor landcover trends. Cartographic geographical registry with other GIS data bases is a secondary issue of particular significance to these applications.

## Methodology

A supervised classification using training samples typical of the cover type to be classified was undertaken. Because of its size the approximately 6 million acre Adirondack Park offers a spectrum of landcover sites from which to choose training samples; however, the study area is split by four Landsat scenes (Path 15; Row 29, 30 and Path 16; Row 29, 30). An examination of available data revealed that during the period 1970 to 1979 very few acceptable data choices were open mainly because of cloudy conditions in scenes recorded. The dates chosen for a recent data set (Path 15 - August 22, 1978 (Scene I.D.'s 83017015011, 83017015014) and Path 16 - June 30, 1978 (Scene I.D.'s 83011715061, 83011715064) enabled cloud free full foliage data within a single season. However, the only cloud free data available at the beginning of the period was leaf off data for October 10-11, 1972. Initially, use of cloud free data was regarded as a priority concern and an attempt made to compare results using full foliage versus leaf off data.

The proposed digital analysis (a supervised classification) was to be undertaken by a contractor with the Agency determining training samples and verifying the classification results.

## Training Samples

Training samples were determined in each Landsat scene within the study area. These included forested type such as hardwoods (beech-birch-maple and birch-aspen types), spruce-fir, pine (as well as pine plantations), wet conifers (black and red spruce, larch and white cedar lowlands) and cut hardwoods (crown cover reduced by approximately 30%). No attempt was made to separate mixed woods . Non-forested training samples included areas of water, deep soil excavation, residential and commercial development, wetlands, grassland, brushland, pasture and agricultural cultivation.

Training sites were determined by using field verification of 1978 1:24,000 scale panchromatic photography to select areas representative of the cover type. Where possible the same sites were used for training on the 1972 images if photo verification revealed that no cover change had occurred on the site during the period covered by available photography (1968 and 1978).

## Evaluation

Completion of the final scene classification was an iterative process, involving several digital classification runs on each scene followed by field/photo evaluation and entry of new training sites, until a final product representing an acceptable interpretation of the data was derived.

After each supervised classification was produced, the areas covering 4 to 5 7½ minute quadrangles were extracted from the four classified images. Quadrangles were systematically checked for accuracy to determine consistent errors and to identify areas for new training sites.

Ground truth verification revealed the following characteristics of the eventual 1978 classification.

1)   Areas classified as conifer were conservative.

2)   The hardwood classifier included mixed hardwood-conifer situations.

3)   Emergent wetlands could not be differentiated from mesic grass lands (apparently because of dry conditions).

4)   The pasture classifier included occasional houses and lawns in woodlands, hardwood woodlands disturbed by cutting, blowdown, or pests.

5)    Wet shadowed bedrock out croppings on steep slopes were classified as water.

6)    Pine consistently identified both pine and hemlock while spruce-fir included pine as well as spruces and fir.

7)    The pasture, brush, exposed soil, agricultural and urban categories consistently occurred in areas with a disturbed land-scape.

## Statistics

The 1978 classification revealed that 83% of the Adirondack Park was forested with 17% classified as non-forested.  Forested categories included northern hardwoods (56%), spruce-fir (19%), pine and pine plantation (8%).

Because the classification of the October, 1972, data (which eventually involved the use of approximately 50 training sites and 3 classification interations) consistently underestimated forested areas, particularly hardwoods, use of that data for a complete landcover classification was abandoned.  New full foliage data was secured for other dates and is currently being processed.

Useful comparisons could, however, be made between the 1972 and 1978 data by limiting the categories compared.  Changes from forested in 1972 (a conservative estimate of forested areas) to pasture in 1978 (the classifier which included disturbed forest land) were found to accurately delineate forest land disturbance due primarily to timber cutting.  A 9-pixel moving window com-parison was used to determine these changes in landcover.  Field verification showed that this technique identified areas of clearcutting for timber removal and clusters of new buildings.

## Geographic Information System

As the landsat landcover project demonstrated its usefulness by providing rapidly available and reliable data to the Agency; a GIS, in part, to accept and enhance the Landsat data was designed and implemented.

Five primary information management goals were identified for the digital component of the GIS including:    1)  digital data storage (in raster format); 2)  planning analysis capabilities; 3) the ability to rescale mapped data; 4)  access to remote data sources and 5)  Landsat processing capabilities.   The computer operated component of the GIS was designed to enhance existing manually stored information and to prepare hardcopy maps which were compatible with the existing map file.   The system was to be constructed under contract and delivered in working order with certain basic data entered to the Agency.

## Hardware

The system delivered consists of 1) a micro-computer with 64kB of memory as the central processing unit of the system; 2) a custom designed hard disk system having a total of 96 megabytes of storage, of which 80 mb are contained in a non-removable disk and 16 mb in a removable disk pack; 3) a 1600 BPI tape drive unit which serves as a data backup and rescue to the disk drives (data can be moved between the system and remote sources using the tape drive unit or floppy disks); 4) a dot-matrix printer with a wide range of symbols and characters which provides grey-scale mapping and will print a 7½ minute quadrangle map at scale in 2 sections; 5) a color monitor with 128 kB of memory, capable of displaying 512 by 480 pixel image.

Mapped data can be entered from a variety of sources using a 54" x 36" digitizing tablet.

## Software

Because the GIS is operated by and serves a diverse professional staff and lay person constituency untrained in programming skills the software operating the GIS is user-friendly and operates in an interactive mode. The software does however offer the opportunity to communicate with other remote digital data bases which do not necessarily operate in a user friendly atmosphere.

A raster system for software operation, as opposed to a polygon, was chosen because of its lower cost for data storage, equipment acquisition, and analysis. The software performs planning analyses including multi-variable geographic combination, coincidence of variables, capability analysis and weighted variability analysis. The choice of raster format effectively limits the usefulness of the system to produce certain types of line oriented cartographic products from stored data.

Data can be accessed on the basis of a micro grid structure based upon the 7½ minute series quadrangle maps which coincides with the Agency's manual map file system. Analysis of data, including Landsat processing, is most effectively accomplished on a small area basis (e.g. quad by quad); analytic results can then be stored within the macro-grid the overall Park area, for further aggregation and analysis.

Additionally the software is designed to incorporate a data base management methodology which will enable access to complex data variables and an attribute file geographically keyed to the content of the raster data file.

## Data Entry and Storage

The GIS raster system is based upon a square 1 acre cell structure. This size allows an accurate portrayal of the Park Plan Map, the land use area map forming the basis of the regulatory and planning program of the Agency, and is compatible with Landsat data. By using the NYS UTM grid to define the perimeter of each cell, the grid cell structure established in the GIS can be easily referenced to the Agency's existing cartographic data base, especially the USGS 7½ minute quadrangle series, for data entry and retrieval.

Three park-wide data variables, including private and state land classifications, unique natural and cultural features, and land cover data from 1978 Landsat overflights, comprise the initial system data. A fourth parkwide data base, political boundaries stored in polygon four, is used in conjunction with other data.

Data in each variable entered is in a 4 bit format, with the option of using an 8 bit format for a variable file which exceeds 15 subclasses. File headings describe the content and location of each variable file and identify associated attribute files developed to enhance the information available for description of variables at a given site. Each Parkwide gridded in 4 bit code occupies 7.5 mb 7 disk storage space. Using a 4 bit code, the 80 mb fixed disk pack system will have the capacity to store 9 or more parkwide data files, on line at one time. Additional data files, two per removable disk pack, can be accessed on the removable disc pack channels for increased flexibility.

These data files are central to Agency conerns about forest cover change because they relate the administrative and regulatory rules of the Agency to observed changes in land cover in the land cover files.

## Land Classification and Boundaries

The classification of land on the Adirondack Park Land Use and Development Plan Map (APLUDP Map) and the State Land Master Plan Map (SLMP Map) were digitized from 199, 7½ minute series quadrangle maps contained in the Agency's manual file system. These maps include UTM reference coordinates and contain 15 sub-classes.

The Adirondack Park Land Use and Development Plan Map, one of two major elements, incorporated into the "Classification of Land" GIS file, describes the classification of all private land in the Park into discrete land use areas. Three major land capability factors determine these land use areas including the natural resource amenability to development, the level of available public services and the open space attributes of the land in question

(14). There are seven (7) classifications on the Park Plan Map, such as Hamlet, Industrial Use, and Resource Management.

In addition, the SLMP Map shows nine (9) categories, such as Intensive Use and Wilderness, for all state lands of the Park; these classifications define recreational use potential based upon existing uses, wilderness character and the capacity of the land to sustain various levels of recreational use (15).

Political boundaries entered as UTM vertices from a 1:250,000 series planimetric map include all minor and major municipalities within the Park, 112 counties, towns and villages. These data were converted to and are stored as study area cell vertices to be used to extract data from other Parkwide gridded data sets.

The Land Classification and Boundary data files will serve to define areas within which to aggregate and report data. Additionally, the classification of land has regulatory implications as well as associated policy goals applicable to the development or use of land within the Park. The classification of private land determines such regulatory requirements as the permitted density at buildout, the required minimum shoreline setback for new structures or the types of new development which would require "building permits."

A primary use of the data in relation to landcover can be to determine, using coincidence of variables operations the distribution of land classification entities (as acres) by Landcover type. This information would reflect, in a general fashion, the impact of Agency regulations on clearcutting as well as on other potential development.

Furthermore, as classifications are modified by amendment these aerial figures can be easily updated.

Unique, Natural and Cultural Features

The presence of Unique, Natural and Cultural Features were digitized as point data. An associated attribute file has been created from data currently stored in notebooks. Sites in the data file consist of key plant and animal habitats, rare and endangered species locations, key geologic sites, historic sites, and potential or existing hydropower sites.

Initially the attribute file information will be digitally analyzed to determine the distribution of sites by categories, such as rare species or waterfalls. Sites which are sensitive to disturbance will be identified and mapped for use in the Agency's regulatory program and the administration of state land units. Using a proximity operation sites in the vicinity of disturbed landcover can be identified as a measure of the environmental impact impinging on the sites.

## APPLICATIONS OF FOREST COVER DATA IN GIS

Because the landcover change analysis is incomplete, illustrations of GIS integration of forest cover change analysis relevant to biomass energy management have yet to be performed. At some point, a Parkwide data file containing areas of forest cover loss and infill will be created and utilized in multivariable combinations in the GIS. Pending the availability of this change data, other applications of current data variables which are illustrative of the same combinations possible with forest change data have been developed. These comparisons, discussed below, utilize 1978 forest cover data in combination with other GIS data files.

The impact of varying degrees of land use regulations can be determined by an analysis of the coincidence of forested landcover types with categories of land classification. For example, the percentage of forested land which could be removed from production by urban uses can be estimated by determining the acreage of forested land in the land use categories of Hamlet, Moderate Intensity and Low Intensity, those areas with high densities of permitted development. Similarly, the same analysis can be performed using other proposed variables or existing GIS variables, such as Unique, Natural and Cultural Features sites. A prototype analysis performed for a Park County (Table 1) compares the landcover characteristics within approximately ½ mile of two categories of UNCF sites, to which differing regulatory protection goals relative to protection from a landcover removal would be applied. These are, first, historic sites (mainly reflecting buildings or registered sites) and secondly, natural areas (including habitats of protected plants or animals). Conversely this analysis demonstrates the comparative vulnerability of these categories to unregulated removal of landcover. A major limitation of the existing source data, that only the occurrence of a site in the location has been recorded rather than the extent of the feature, can be corrected by digitizing polygons of the features to delineate their area. This method was tested in a local application of the GIS data. The print data does provide an indication that a feature exists in the area.

## Locality Application

One of the 112 municipalities within the Park has cooperated in more detailed analytic work as part of its local planning effort. More detailed and varied data was digitized and entered into a gridded data base established for the Town of Duane, in Franklin County. These data elements included meso level soil boundaries, slope categories, UNCF polygons and travel corridors.

An interesting application was to determine the landcover characteristics of deerwintering areas as reflected in state resource maps (Table 2). Deer wintering areas are thought of mainly as sheltered coniferous areas; the analysis showed,

however, that extensive hardwood areas were included within the wintering areas. Assuming the initial boundary is accurate, the hardwood areas may be important for feeding or movement from one conifer patch to another.

Another application, developed by combining limitations of soil and slope categories with landcover, examines the availability of timber for harvest (Table 3). By adding other variables, such as road location, scenic and recreational values, and ownership patterns, the regulatory implications of varying proposed local regulations controlling logging on timber availability can be explored.

## Conclusion

Introduction of a GIS to a professional staff without computer or landsat processing experience points to the following conclusions:

- o timely access to both current and historic raw landsat data and its cost is a very signficiant consideration in its useful application.

- o user-friendly micro-computer technology is an effective means of extending staff effectiveness by automating labor intensive cartographic analysis if digital data such as landsat are available.

- o quantitative forest cover change analysis can be determined with a high degree of reliability in the northern hardwoods of the Adirondacks if high quality full foilage data is available. (Another NYS Agency is presently evaluating qualitative analysis using supplementary resource and economic data such as found in the Agency GIS and other state record systems).

The chief advantages of the GIS are the ability to generate inexpensive resource inventories for large land areas with a relatively high degree of reliability and accuracy. The digitized data is easily manipulated and compared to other data in the GIS. Its use as a tool to monitor landcover changes has not been fully demonstrated although a limited application realized some return.

Beyond the completion of the temporal landcover analyses, anticipated capabilities include the integration of new data such as soils and elevation into the GIS to help to increase the accuracy of the interpretation of landsat landcover data and provide additional variables in analysis. In addition the GIS data, particularly soil characteristics, could be used as a weighted variable in a Landsat classification run to increase the accuracy of classification.

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## Table 1

DISTRIBUTION OF LANDCOVER WITHIN 14 PIXELS (½ mile) OF
UNCF SITES IN CLINTON COUNTY

| Landcover Type | Historic Sites (% of area) | Natural Sites (% of area) |
|---|---|---|
| Hardwood | 12 | 30 |
| Spruce/fir | 25 | 31 |
| Pine | 5 | 11 |
| Pine Plantation | 6 | 5 |
| Wet Conifer | 3 | 5 |
| Pasture | 11 | 3 |
| Grassland | 2 | 1 |
| Brush | 0 | 1 |
| Agriculture | 10 | 1 |
| Exposed Soil | 2 | 0 |
| Urban | 7 | 1 |
| Water | 17 | 13 |
| Total Forested | 51 | 82 |
| Total Disturbed | 32 | 5 |

## Table 2

LANDCOVER FOR DEERWINTERING AREAS IN THE TOWN OF DUANE

| Landcover Type | Acres | Percent |
|---|---|---|
| Hardwoods | 5415. | 46.06% |
| Spruce/Fir | 3141. | 26.72% |
| Pine | 931. | 7.92% |
| Wet Conifer | 607. | 5.16% |
| Pasture | 235. | 2.00% |
| Brush | 32. | .27% |
| Grassland | 7. | .06% |
| Agriculture | 16. | .14% |
| Exposed Soil | 0. | 0.00% |
| Urban | 13. | .11% |
| Pine Plantation | 896. | 7.62% |
| Water | 463. | 3.94% |
| Totals: | 11756. | 100.00% |

Table 3

COINCIDENCE OF LANDCOVER/DEVELOPMENT LIMITATIONS
IN THE TOWN OF DUANE

| Landcover Type | Degree of Physical Limitation | | | |
| --- | --- | --- | --- | --- |
| | Moderate | Severe | Overriding | Total |
| | (acres) | (acres) | (acres) | (acres) |
| Hardwoods | 2,643 | 17,621 | 10,999 | 31,263 |
| Spruce/Fir | 1,450 | 6,930 | 11,531 | 19,911 |
| Pine | 343 | 1,809 | 703 | 2,855 |
| Wet Conifer | 177 | 1,123 | 409 | 1,709 |
| Pasture | 196 | 575 | 92 | 863 |
| Brush | 9 | 92 | 98 | 199 |
| Grassland | 31 | 22 | 32 | 85 |
| Agriculture | 68 | 80 | 4 | 152 |
| Exposed Soil | 4 | 0 | 4 | 8 |
| Urban | 38 | 31 | 12 | 81 |
| Pine Plantation | 403 | 1,907 | 110 | 2,420 |
| Water | 86 | 422 | 1,644 | 2,152 |
| Totals: | 5,448 | 30,612 | 25,638 | 61,698 |

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The Geographic Information System described in this paper is an
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