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STRATEGY FOR SELECTING USGS LAND USE AND LAND COVER MAPS FOR PHOTOINSPECTION

By Valerie A. Milazzo

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CONTENTS

ILLUSTRATIONS

TABLES

STRATEGY FOR SELECTING USGS LAND USE AND LAND COVER MAPS FOR PHOTOINSPECTION

By Valerie A. Milazzo
U.S. Geological Survey
Reston, Virginia 22092

ABSTRACT

To meet the increasing demands for current land use and land cover information, a primary goal of the U.S. Geological Survey's national land use and land cover mapping program is to update existing maps and data in a timely and uniform manner. Both the specifications dealing with the cartographic and interpretive aspects of mapping land use changes and those procedures that are followed after a map has been chosen for updating have been developed. An important component of the map updating process, however, involves the procedures for first determining what land use and land cover maps are to be updated. In the U.S. Geological Survey, a photoinspection procedure is used to select maps for revision. In photoinspection, maps are compared with the most recent remotely sensed source materials available to identify those maps that are out-of-date and need revision. Since not all maps can or need to be photoinspected at the same time, a procedure is needed to target specific maps for photoinspection.

A strategy for selecting maps for photoinspection prior to updating is proposed that is straightforward, objective, standardized, and repeatable. Candidates for photoinspection are identified using selection criteria based on land use and land cover environment type (change potential), age of the data, date of last photoinspection, and availability of remotely sensed source materials. Only those maps that meet all of the selection criteria are targeted for photoinspection. In a computer-based system for automating the targeting procedure, specific attribute data would be stored for each map. Maps fitting any combination of specified attribute data with regard to photoinspection selection can then be retrieved and listed. By providing this information quickly, the computer can be used effectively in targeting maps for photoinspection and in streamlining many of the decision elements in the selection process.

BACKGROUND

Since 1974, the U.S. Geological Survey (USGS) has been engaged in nationwide baseline mapping of land use and land cover and associated data at a scale of 1:250,000. As 1:100,000-scale base maps have become available, they have been used for special applications and for mapping certain areas. These scales are appropriate for mapping land use and land cover data on a nationwide basis within a practical time frame, and with an acceptable degree of standardization, accuracy, and level of detail. The map set provided under this program consists of the following:

1) Land Use and Land Cover
2) Political Units
3) Hydrologic Units
4) Census County Subdivisions
5) Federal Land Ownership (provided only in cooperative mapping programs or when complete States or regions are mapped)
6) State Land Ownership (provided only in cooperative mapping programs when data are supplied by cooperator)

Land use and land cover has been mapped using remotely sensed data at Level II of the classification system presented by Anderson and others (1976) (see table 1), and using the map compilation specifications documented by Loelkes (1977). This provides a systematic and comprehensive land use and land cover data base which is uniform in categorization level and cartographic portrayal for the entire United States.

The associated maps provide selected natural or administrative data. These allow users to relate or extract the graphic or statistical information on land use and land cover for the areas portrayed on the associated maps.

As part of this program, the land use and land cover and associated data are digitized and the information is stored in digital format. A computerized geographic information system described by Mitchell and others (1977) has the capability to input, store, manipulate, and retrieve the data. The system makes possible the generation of digital data-base tapes and a wide array of graphic and statistical output products that can be used by planners, resource managers, and others at national, regional, State and other agency levels.

INTRODUCTION

Current maps and map data are needed for effective planning, management, and utilization of the Nation's land resources. Since land use and land cover conditions change with time, there is a need to periodically revise maps and data to reflect these changes.

A primary goal of the U.S. Geological Survey national land use and land cover mapping program is to update existing maps and data in a timely and uniform manner. Alternatives for updating USGS land use and land cover maps have been evaluated (Milazzo, 1980). It has been recommended that a map-updating procedure be established that is timely, cost-effective, and standardized, that portrays an appropriate level of information, that achieves an acceptable measure of accuracy, and that relates to and builds upon the existing data base.

Map updating can be described as a three-step process consisting of:

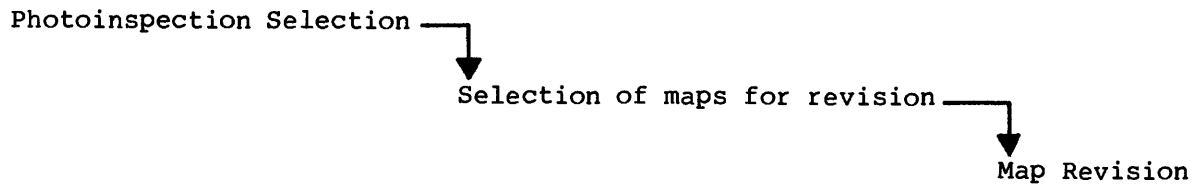

Table 1.--U.S. Geological Survey Land Use and Land Cover Classification System for Use with Remote Sensor Data [From Anderson and others, 1976].

LEVEL I		LEVEL II	
1	Urban or Built-up Land	11	Residential
		12	Commercial and Services
		13	Industrial
		14	Transportation, Communications and Utilities
		15	Industrial and Commercial Complexes
		16	Mixed Urban or Built-up Land
		17	Other Urban or Built-up Land
2	Agricultural Land	21	Cropland and Pasture
		22	Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas
		23	Confined Feeding Operations
		24	Other Agricultural Land
3	Rangeland	31	Herbaceous Rangeland
		32	Shrub-Brushland Rangeland
		33	Mixed Rangeland
4	Forest Land	41	Deciduous Forest Land
		42	Evergreen Forest Land
		43	Mixed Forest Land
5	Water	51	Streams and Canals
		52	Lakes
		53	Reservoirs
		54	Bays and Estuaries
6	Wetland	61	Forested Wetland
		62	Nonforested Wetlands
7	Barren Land	71	Dry Salt Flats
		72	Beaches
		73	Sandy Areas Other than Beaches
		74	Bare Exposed Rock
		75	Strip Mines, Quarries, and Gravel Pits
		76	Transitional Areas
		77	Mixed Barren Land
8	Tundra	81	Shrub and Brush Tundra
		82	Herbaceous Tundra
		83	Bare Ground Tundra
		84	Wet Tundra
		85	Mixed Tundra
9	Perennial Snow or Ice	91	Perennial Snowfields
		92	Glaciers

In this process the actual cartographic updating of a map is the final step. The technical specifications for updating land use and land cover maps have been developed (Milazzo, in review). These specifications deal with the cartographic and interpretive aspects of map updating that are followed after a map has been selected for revision. An important step in the map updating process, however, is to first determine what land use and land cover maps need updating. In the USGS, a photoinspection procedure is used to select maps for revision. In photoinspection, maps are compared with the most recent remotely sensed source materials available to identify those maps that require revision. Since not all maps can or need to be photoinspected at the same time, a procedure is needed to target specific maps for photoinspection. The procedure for identifying maps to be photoinspected is the first step in the map updating process and the subject of this report.

BASES FOR MAP PHOTOINSPECTION

There are two approaches that can be followed in selecting land use and land cover maps for updating. In the first approach, the need for update can be determined according to elapsed time criteria. An elapsed time or age for land use and land cover map data is established. Each map would be updated after this period of time, regardless of the amount and type of changes that have actually taken place. The time-interval approach to map update frequency has a procedural advantage in that no review or inspection of maps is required prior to updating.

The second approach to selecting maps for updating is based on the criterion of change, where the presence of a specified amount and/or type of change dictates the need for updating, regardless of the time elapsed. Milazzo, (1980) states that land use and land cover maps should be selected for updating primarily on the basis of change, and that the elapsed time component be considered as an important, but only supportive, input.

Since the amount and type of change determines the need for updating, each map must be reviewed periodically with more current remotely sensed source materials to identify such changes. Thus an additional step--photoinspection--is required to identify these changes and to determine update need.

SELECTING MAPS FOR PHOTOINSPECTION

The USGS has developed a policy and procedures for both the photoinspection and subsequent revision of topographic maps. The methodology used in selecting land use and land cover maps for updating should be similar to that developed for the topographic map series. The decisionmaking process in selecting maps for photoinspection should be (1) straightforward, (2) objective, (3) standardized, and (4) repeatable.

Land use and land cover changes occur at highly variable rates. Therefore not all land use and land cover maps need to be updated at the same time. Since it is not possible or necessary to photoinspect all maps at the same time to determine if updating is needed, a procedure should be

developed for targeting specific maps for photoinspection. These are the maps for which photoinspection would most likely indicate a need for update. One way to identify maps as candidates for photoinspection is by subjecting them to a stratification and selection process. Only those maps that meet all of the selection criteria are photoinspected. The five-step selection procedure is illustrated in figure 1.

Grouping Maps According to Change Potential

All land use and land cover maps can be stratified into groups on the basis of change potential, i.e., the relative frequency with which changes might occur, and in terms of the relative importance of the changes with respect to their cultural, economic, and environmental impacts. Maps or portions of maps can be arranged into at least five general groups based on the dominant or characteristic Level II land use and land cover categories portrayed on the maps (table 2). The assignment of maps to a group may be determined by acreage or area percentage in specific categories, as derived from statistical data, or based on whether or not a map contains a significant portion of the categories associated with a particular land use and land cover environment (though not necessarily comprising a majority of the map data). Each map should be placed in the environmental group that best characterizes the land use and land cover on the map. However, because of the diversity of data often contained within the boundaries of a map sheet, it is possible that a map may fall within more than one group. These groups are:

- Dynamic Change Areas.--These are areas characterized by residential subdivision development, highway construction, and other land use and land cover changes associated with urbanization. Such changes occur in very short periods of time. Areas where such changes take place are characterized as "dynamic" environments. Typical of these areas are the Standard Metropolitan Statistical Areas (SMSA's).

  Although the land area involved may be considerably less than for most non-urban categories, the number and frequency of the changes and their far-reaching impact on the landscape make changes in the Urban and Built-Up categories important to identify as frequently as possible.

- Critical Environment Areas.--Critical environment areas are those areas that are of high national concern and interest due to the delicate character of the natural environment. These are areas often unsuited to urban development but areas where, nonetheless, urban encroachment often threatens the natural balance of the environment. Since critical environment areas are subject to periodic natural hazards, unchecked development in these areas poses risks to both life and property. As a result these areas should remain under developmental controls or preserved in a protected natural state. Examples of such environments are active fault zones, wetland areas, floodplains, estuaries, beaches, and other seashore and coastal zone environments.

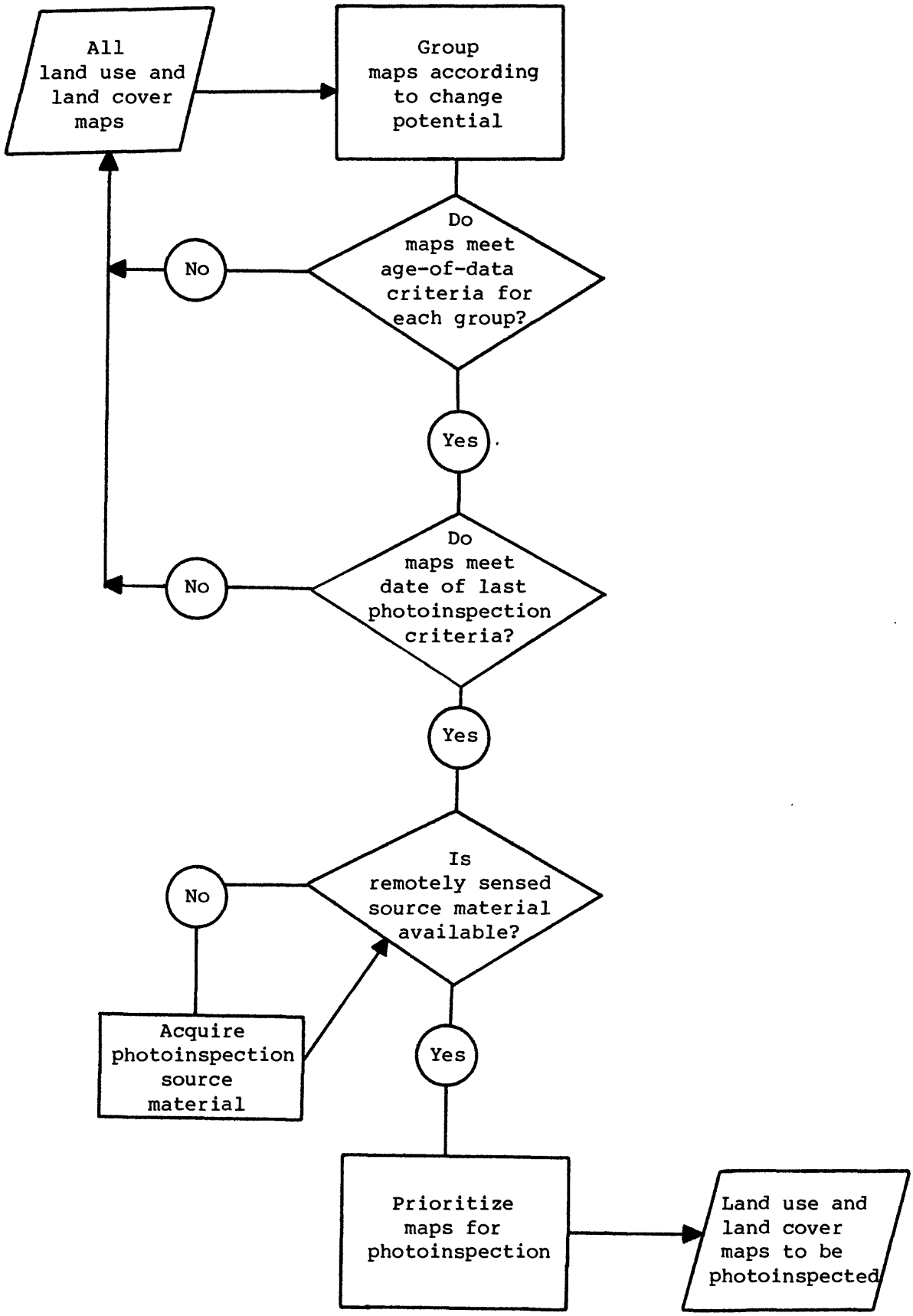

Figure 1.--Decision steps used in selecting maps for photoinspection.

Table 2.--Land use and land cover environments based on a stratification of Level II categories.

Land Use and Land Cover Environment	Level II Categories	Suggested Update Frequency (years)
• Dynamic Change Areas, SMSA's Urban and Built-Up Areas	11-17, 76	5-7
• Critical Environment Areas	51-54, 61, 62, 72	7-10
• Energy Resource Areas	75, 76	7-10
• Agricultural, Rangeland, and Forest Land Areas	21-24, 31-33, 41-43	10-15
• Other Stable Land Areas	71, 73, 74, 77, 81-85, 91, 92	15-20

- Energy Resource Areas.--Land use and land cover maps can be grouped according to areas in which there is a demand for current land use and land cover data based on energy resource interests. These areas are usually associated with coal production, oil extraction, and related natural resources such as natural gas energy development and mineral lands exploration and reclamation.

- Agricultural, Rangeland and Forest Land Areas.--Areas characterized by these types of land use and land cover categories generally undergo little or no change over long periods of time. Such changes, however, do vary regionally and in terms of proximity to major Urban and Built-Up centers. Generally changes in these categories are less critical to identify for map updating purposes. Hence, more change is required before updating is warranted. Since these changes occur relatively slowly, a longer period between revisions is acceptable for maps characterized by these land use and land cover categories.

- Other Stable Land Areas.--In some non-urban areas there is little economic or environmental catalyst for change. In many parts of the arid Southwest having extensive areas of Barren Land or desert vegetation, very little change occurs. Areas characterized by Tundra or Snow and Ice cover also lack frequent change. These areas can be termed as "stable" land environments because of their resistance to change.

In addition to these five environments, land use and land cover maps may also be assigned into two additional groups:

- Areas of Known or Drastic Change.--Maps or parts of maps may require photoinspection because the areas they portray have undergone known changes, such as those due to earthquakes, floods, volcanic eruptions or other natural disasters. Such maps should be reviewed to determine the extent of the changes and whether or not the changes are sufficient to warrant updating the maps.

- Special Requests for Reviews.--There is a demand for current land use and land cover data based on specific user needs. Maps for which cooperative arrangements have been made or user requests for updating received should be reviewed to determine the exact nature and extent of the changes and whether or not updating is required.

Identification of Maps in Each Group Meeting Age-of-Data Criteria

Elasped time is a good indicator of the likelihood of change. Thus land use and land cover maps can be grouped according to the age of the data as determined by the date(s) of the compilation source materials used to compile the maps.

The update frequencies (in table 2) represent suggested time frames for updating the maps within each of the land use and land cover environments based on the likely rates and impact of the changes to be encountered. For example, changes in SMSA's and other dynamic areas are numerous and frequent. Therefore updating of maps in these areas should take place more often than for other areas. For maps covering agricultural or other stable areas where changes are less frequent and numerous, longer periods between updates are acceptable. Regardless of the nature of the changes, however, budget and manpower constraints require that a minimum practical time interval for map update be established. Within the USGS National Mapping Program, at least 5 years is recommended between revisions of land use and land cover maps, given the scale and level of information mapped. This means that the land use and land cover data must be at least 5 years old before a map can be considered for photoinspection.

The age-of-data criteria are general guidelines. Decisions to inspect each map should be made on a case-by-case basis. In some cases, if circumstances indicate that an earlier map update inspection date is warranted and can be accomodated, the age requirement can be shortened or waived.

Identification of Maps Meeting Date-of-Photoinspection Criterion

The maps meeting age-of-data criteria should be further stratified according to the dates they were last photoinspected (fig. 1).

To be targeted for photoinspection, a land use and land cover map must either never have been photoinspected, or it must have been at least 3 years since the last photoinspection.

This 3-year interval between photoinspections is chosen because:

- It provides a reasonable time between photoinspections to allow for sufficient changes to occur which might alter the map,

- The criteria used to evaluate changes during photoinspection are such that a map that is not selected for update probably would not require updating within the next 3 years. However, if an estimate of expected changes indicates that update would be likely sooner than the next allowable photoinspection, revision may be authorized.

Identification of Maps for which Photoinspection Source Material is Available

After candidates for photoinspection have been determined, a search should be conducted to locate current remotely sensed data for the photoinspection. Such source materials include high-resolution aerial photographs, photo indexes, and Landsat multispectral scanner (MSS) or return beam vidicon (RBV) imagery. The remotely sensed data used in photoinspection need not be the same as that used to actually update the map. Since photoinspection is designed to provide a quick assessment of change, rather than to support the detailed mapping of discrete change polygons, a wider range of source materials is available. Landsat imagery is readily available for many areas. Additionally, costs to acquire, process, and use Landsat imagery are relatively low. Landsat also offers frequent repetitive coverage of an area. Thus it is ideally suited for routine monitoring of areas for changes in land use and land cover conditions. For these reasons it is suggested that Landsat MSS and RBV imagery be used in the photoinspection of certain maps when these sources permit the reliable identification and appraisal of changes.

Only those maps for which photoinspection sources are available can be photoinspected. All other maps will be noted as having met the requirements for photoinspection, but were not selected due to the unavailability of such materials. So that these maps may be considered for photoinspection in a subsequent year, a request for the acquisition of photographic coverage should be made when the response to the annual solicitation of requirements and priorities for remotely sensed data is filed.

Priority Grouping of Maps for Photoinspection

Once it has been determined that suitable photoinspection source data are available for a map, it should be assigned a priority for photoinspection. In the event that only a limited number of maps can actually be photoinspected, a priority designation serves as a mechanism for making the final selection of maps to be scheduled for photoinspection.

Any maps not photoinspected because of a low-priority assignment, will be so noted and included in the following year's list of map candidates for photoinspection.

IMPLEMENTATION

This strategy for targeting land use and land cover maps for photoinspection uses a series of questions requiring only a yes or no answer (fig. 1). At each decision point, an affirmative answer moves the map one step closer to photoinspection. Such an objective approach lends itself to computer application. It is proposed that such a system be designed.

In this computer-based system, each map would be identified by specific attribute data relevant to photoinspection selection. Each map would be coded to identify, for example, the following attribute data:

1) map name;
2) land use and land cover environment groups;
3) age of land use and land cover data or date of compilation remotely sensed source materials; and
4) last photoinspection date.

Other elements can be added such as the scale of the map, the States and counties in which the map lies, the regional location, whether or not the map was completed under cooperative arrangements, and whether or not the data have been digitized. Each time a map is photoinspected or updated, a new file would be created in which new entries would be made to update the appropriate attribute data contained in the computer data file for the map.

With these data stored, one could identify maps fitting any combination of attribute data with regard to photoinspection selection or other criteria. For example, one could request a listing of all completed land use and land cover maps, at 1:250,000-scale, that have been digitized, that contain SMSA's within coastal regions on the eastern seaboard, and where land use and land cover data are 7 to 10 years old. By providing such information quickly, the computer can be used to streamline many of the decision elements in selecting maps for photoinspection.

At present, USGS 1:250,000-scale quadrangle maps are used for land use and land cover mapping. At this scale, 273 maps cover the conterminous United States. It may be argued that this number may not justify the developmental costs associated with automating the photoinspection selection strategy. In the future, however, land use and land cover maps may well be produced at larger scales and at different formats as other base maps become available nationwide. (Already, some land use and land cover maps have been produced at 1:100,000-scale in areas where these quadrangle base maps have become available.) At this scale and at larger publication scales, such as 1:50,000 or even 1:24,000, thousands of maps would be produced and eventually updated. The expenditures invested now to develop a viable computerized map update selection procedure will prove to be dollars well spent in terms of future payoffs and applications.

SUMMARY

Since land use and land cover changes occur at highly variable rates from place to place, not all maps need to be updated at the same time. Thus a procedure to select and inspect USGS land use and land cover maps to determine the need for update must be developed. The strategy that has been proposed provides for targeting a limited number of maps for photoinspection based on a series of stratification and selection criteria. Only those maps that meet the required selection criteria are then targeted for photoinspection.

Five steps have been suggested for targeting land use and land cover maps for update photoinspection. These are:

1) Group maps according to change potential.
2) Identify maps in each group meeting age-of-data criteria.
3) Identify maps meeting date-of-photoinspection criterion.
4) Identify maps for which photoinspection source material is available.
5) Prioritize maps for photoinspection.

The selection strategy is straightforward, objective, standardized, and repeatable. By design, it involves only five steps, thus making the selection routine both easy to use and inexpensive to operate. Since it is a logic-based approach, it is well-suited to digital computer application. A computerized query system should be implemented where possible to automate and streamline the procedures for selecting land use and land cover maps for photoinspection. By automating the selection process, further reductions in time and cost are possible, thereby enhancing the efficiency and effectiveness of the system. It is recommended that development of a demonstration test be undertaken.

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