Land Use Methods & Metrics Development Outcome

Management Strategy

Introduction

To minimize the extent of and mitigate effects of land conversion, local decision-makers and the land conservation community need to be informed about land cover and use changes that affect valued ecosystems, landscapes, and social services; and policy options, incentives and tools to reduce the rate and magnitude of conversion of those lands. To address the first part of this strategy, the Land Use Methods and Metrics Development Outcome calls for monitoring and reporting on the rates of farmland, forest and wetland conversion and the rate of impervious surface change at a local scale relevant to land use decisions. The Metrics Outcome will help inform outreach efforts and products developed as part of the Land Use Options Evaluation Outcome which will address the second part of this strategy.

The intent of the Metrics Outcome is to develop a method and metrics to monitor the conversion of valued natural and working landscapes, such as forests, wetlands and farms and to better understand the impacts of land conversion. Natural and working landscapes provide ecosystem services of value to the Chesapeake Bay and its population including water quality and quantity, habitat, recreation and food production.

I. Goal, Outcome and Baseline

This management strategy identifies approaches for achieving the following goal and outcome:

Goal: Conserve landscapes treasured by citizens in order to maintain water quality and habitat; sustain working forests, farms and maritime communities; and conserve lands of cultural, indigenous and community value.

Outcome: *Continually improve the knowledge of land conversion and the associated impacts throughout the watershed. By 2016, develop a Chesapeake Bay watershed-wide methodology and local level metrics for characterizing the rate of farmland, forest and wetland conversion, measuring the extent and rate of change in impervious surface coverage and quantifying the potential impacts of land conversion to water quality, healthy watersheds and communities. Launch a public awareness campaign to share this information with citizens, local governments, elected officials and stakeholders.*

Baseline and Current Condition: The temporal baseline for the outcome has not yet been determined but will be based on observed landscape changes within the 2005-2015 timeframe and be repeated every two to five years. The baseline may also vary by jurisdiction depending on data availability.

The economy, consumer preferences, and public investments influence the decisions of private developers and businesses which in turn influence the migration of people seeking jobs and amenities resulting in both commercial and residential growth. These factors, however, can be unpredictable and volatile as witnessed in the steep decline in new housing starts from 2006-2009 following the housing boom. Therefore, measures of land conversion should be interpreted in context, relative to measures of economic activity such as population growth due to migration and episodic large-scale infrastructure projects and relative to data on land protection and zoning.

II. Participating Partners

The following partners have pledged to help implement this strategy:

- Chesapeake Bay Commission
- Local Government Advisory Committee
- Water Quality Goal Implementation Team
- Habitat Goal Implementation Team
- Healthy Watersheds Goal Implementation Team
- Maryland Department of Planning
- Pennsylvania Department of Community and Economic Development

- U.S. Geological Survey
- USGS National Geospatial Program
- The Chesapeake Conservancy

Local Engagement: To assist in quantifying impacts on communities, the Land Use Workgroup will work with the Local Government Advisory Committee (LGAC) to identify local governments interested in participating in quantifying the impacts of land use change on communities and the environment. Local government stakeholders are needed to advise the Chesapeake Bay Program on the development of the methodology and local level metrics, and in quantifying potential impacts.

III. Factors Influencing

The following are natural and human factors that influence the Bay Program's ability to attain this outcome:

1. The Bay Program Management Board has interpreted the Outcome language as calling for the development of separate metrics for forest, farm, and wetland conversion in addition to measuring the rate of impervious surface change. Thus, addressing this Outcome will require metrics that account for conversions from forests to farms and from farms to forests, in addition to conversions of both forests and farms to development.
2. High-resolution land cover and elevation data availability and costs. The Bay Program Partners have collectively invested over $2 million for 2013-14 1m-resolution land cover data for the Bay watershed. Future costs for 2018/19 dataset may be reduced due to improvements in techniques and technology, however, they will still be considerable. LiDAR-derived surface elevation data (Figure 4) is currently available for about 70% of the Bay watershed and is more expensive than high-resolution land cover data. Advancements in technology and economies of scale for broad area collection efforts are likely to reduce the costs of such data in the future. Sustainability of long-term monitoring. This factor is a question of political will more than technological capabilities.
3. Methodology for assessing landscape change with high-resolution data with sufficient precision to inform county-level decisions. Techniques to separate actual change in land cover from background noise and sources of confusion are rapidly advancing but are not sufficiently established to make this a non-issue.
4. Methodology to quantify impacts to communities and the environment. The quantification of impacts from land conversion to communities and the environment needs to be explored in more detail. Quantification of impacts without sufficient context for interpreting those impacts may lead to false conclusions.
5. Agreement on the temporal and spatial scale at which to assess change. This is both a fiscal and practical issue. Monitoring at shorter intervals, every 2-3 years, will require higher accuracies and sensitivities to detect the amount of change expected over such short intervals not to mention an increase in costs. However, monitoring every 4-5 years may not provide sufficient temporal resolution for elected officials and managers to respond in a timely manner.

IV. Current Efforts and Gaps

The term "land cover" refers to a wall-to-wall classification of land surface characteristics into categories such as impervious surfaces and tree canopy. Land cover classifications are derived from aerial and satellite spectral imagery collected from passive sensors. These classifications can be enhanced by incorporating data from active sensors. Since the late 1990’s, the Bay Program hasrelied on 30m-resolution Landsat satellite derived land cover data to provide a spatially consistent representation of Chesapeake Bay watershed conditions to inform the suite of models used for management purposes and for tracking changes on the landscape. The U.S. Geological Survey has produced comparable land cover data derived from Landsat imagery for the Bay watershed for 1984, 1992, 2001, 2006, and 2011. These data are invaluable for highlighting hot spots of change and for informing the Bay watershed model but they can largely miss the development of 2-lane roads and low-density residential areas. While these data have an overall accuracy above 80%, this is likely insufficient for monitoring change at the county-level every 3-5 years.

Throughout the 2000’s and present day, counties, states, and the United States Department of Agriculture’s (USDA-FSA) Farm Service Agency have acquired high-resolution (<=2m) imagery to inform transportation, public works and natural resource decisions. Initially, these data were acquired as natural color images and used as pictures rather than analyzed as data. This practice has gradually evolved through the development of object-based feature extraction software, such as Feature Analyst, ENVI and eCognition as well as the acquisition of imagery with a near-infrared spectral band in addition to the three visible bands. The near-infrared band enhances the ability to distinguish vegetation from non-vegetated areas.

At present, USDA-FSA collects four-band leaf-on one-meter resolution ortho-imagery for each state as part of their National Agriculture Imagery Program (NAIP) every 1-3 years. Collection dates are cyclic and vary due to the availability of state cost-share funds and other factors. The Virginia Institute of Marine Science (VIMS) collects and manually classifies black and white aerial photographs along the near-shore areas of the Chesapeake and Coastal Bays to support their annual inventory of submerged aquatic vegetation (SAV) extent and density. In addition, some states and localities acquire sub-meter leaf-off imagery every 3-5 years to support transportation and planning needs. Leaf-on imagery is better for detecting vegetation and leaf-off imagery is better for detecting impervious surfaces and water features which may be obscured by the canopy during the growing season. Leaf-off imagery is mostly collected during the spring, but the collection years often vary by state.

Complete or partial land cover information derived from classifying high-resolution imagery is available only for select counties in the watershed (Figures 1-3). In 2015, 1m land cover data will be produced for the entire Bay watershed (including all adjacent counties) using a combination of 2013/14 leaf-on and leaf-off imagery combined with surface elevation data derived from LiDAR or stereo imagery. These data will be publicly available and include the following classes: impervious surface (roads), impervious surface (other), tree canopy, tree canopy over impervious surface, scrub-shrub, herbaceous, barren, water, and emergent wetlands.

The Metrics Outcome calls for “continually improving the knowledge of land conversion” which requires monitoring land change, not just mapping it once. Assessing and mapping land use and cover change from high-resolution imagery is challenging but holds great promise for meeting the objectives of this outcome. Changes in spectral surface properties over multi-date images are influenced by differences in sun-angle, atmospheric conditions, vegetation phenology, infrastructure materials and aggregates, and other factors besides land cover changes that can change from one image tile to another and from one year to another. These problems are largely absent when performing a change analysis on 30m-resolution Landsat satellite imagery. High-resolution change analysis can be done, but for the above stated reasons, first-round automated results will likely be noisy and require modification to realize the accuracies needed to detect the average amount of change we expect to observe over a 2-5 year interval.

V. Management Approaches

There are three elements to the Metrics Outcome:

1. Monitor the conversion of forests, wetlands and farmland.
2. Quantify impacts of land conversion on:
    a. Water quality
    b. Healthy watersheds
    c. Communities
3. Communicate results to the public, elected officials and to the Bay Program.

The Bay Program will coordinate and solicit input on user requirements and technical specifications for this outcome. There are three basic technical approaches for monitoring land conversion every 2-5 years: 1) coarse, 30m-resolution wall-to-wall mapping of land cover change from Landsat satellite imagery; 2) high-resolution (<5m) wall-to-wall mapping of land cover change from aerial or satellite imagery; and 3) high-resolution (<5m) stratified random sampling. Each of these options has advantages and disadvantages related to cost, accuracy, spatial and temporal scale, flexibility for management use, adaptability to changing management objectives and educational value. These attributes will be considered in developing recommendations for monitoring land change over time. Additional options may emerge from internal discussions and potential data providers over the coming year.

Note: that the above options are not necessarily mutually exclusive. For example, monitoring land change with Landsat satellite imagery can inform a stratified sampling framework using high-resolution imagery.

While measuring current rates of land conversion will require use of existing imagery and data which varies in spatial resolution, accuracy and temporal currency, significant improvements in derived metrics and cost savings to local, state and federal government agencies could be achieved through a heavily coordinated effort to synchronize the acquisition of imagery and agree on a classification schema and change detection approach.

Quantifying the impacts of land conversion on water quality will be accomplished through close coordination with the Bay Program Modeling Workgroup and utilize the same sets of assumptions and data used to inform water quality decisions associated with the Chesapeake Bay Total Maximum Daily Load (TMDL). Quantifying impacts to healthy watersheds will be determined through close coordination with the Healthy Watersheds Goal Implementation Team (GIT) and may involve measures of vulnerability to urban development coupled with hydrologic impact measures associated with stream flow alteration. Assessing the impacts of land conversion to communities is one of the most complicated aspects of this outcome. Land conversion associated with residential and commercial development provides economic benefits to communities, but also involves costs that are not always evident at the time of development. Local participation will be sought to help identify and describe impacts to communities and to develop and implement the communication strategy as described below.

Approaches Targeted to Local Participation

Local participation in the methods - particularly those used to assess impacts to communities- are needed to ensure the data are useful for informing local-level decisions. The Bay Program Healthy Watersheds GIT, Citizen Advisory Committee (CAC), and LGAC will work with the Bay Program Land Use Workgroup and Communications Office in group forums to develop a communication strategy and to identify the specific measures used to assess to water quality, healthy watersheds and communities. These groups will further work together to seek additional local government and nongovernmental participation and leadership for implementing the communication and outreach strategy. Additional outreach to local governments will occur to engage them in the development and interpretation of land conversion metrics.

Cross-Outcome Collaboration and Multiple Benefits

Restoration and conservation efforts in the watershed would benefit from the availability of high-resolution land cover and elevation data produced every 3-5 years. The data would inform goals outlined by all of the Bay Program's GITs and inform almost all of the outcomes specified in the Chesapeake Bay Watershed Agreement—particularly the Vital Habitats, Healthy Watersheds, and Land Conservation Outcomes. Specific benefits include:

- Characterizing, mapping, and tracking of wetlands, riparian forest buffers, forests and impervious surfaces;
- Characterizing, mapping, and tracking habitat conditions;
- Developing habitat suitability maps;
- Prioritizing and targeting restoration, conservation, education and public access efforts;
- Understanding the effects of management actions on water quality;
- Verifying riparian buffer and urban tree canopy Best Management Practices;
- Identifying areas of bank erosion, channel incision and floodplain sediment deposition;
- Improving the accuracy of nutrient and sediment load estimates; and
- Educating people on the value and location of high-functioning landscapes

VI. Monitoring Progress

N/A

VII. Assessing Progress

Progress in developing the methods and metrics will be assessed quarterly by the Land Use Workgroup and will be based on the feasibility and accuracy of the derived metrics and impact measures. Following development and approval of the metrics, they will be reassessed every 3-5 years corresponding to the receipt of updated land cover information.

VIII. Adaptively Manage

The utility of the metrics and impact assessments for informing Bay Program decisions will be evaluated at the end of each monitoring cycle and adjusted as needed to improve their utility for local decisions to accommodate changes in technology and programs.

IX. Biennial Workplan

Biennial workplans for each management strategy will be developed by December 2015. It will include the following information:

- Each key action
- Timeline for the action
- Expected outcome
- Partners responsible for each action
- Estimated resources

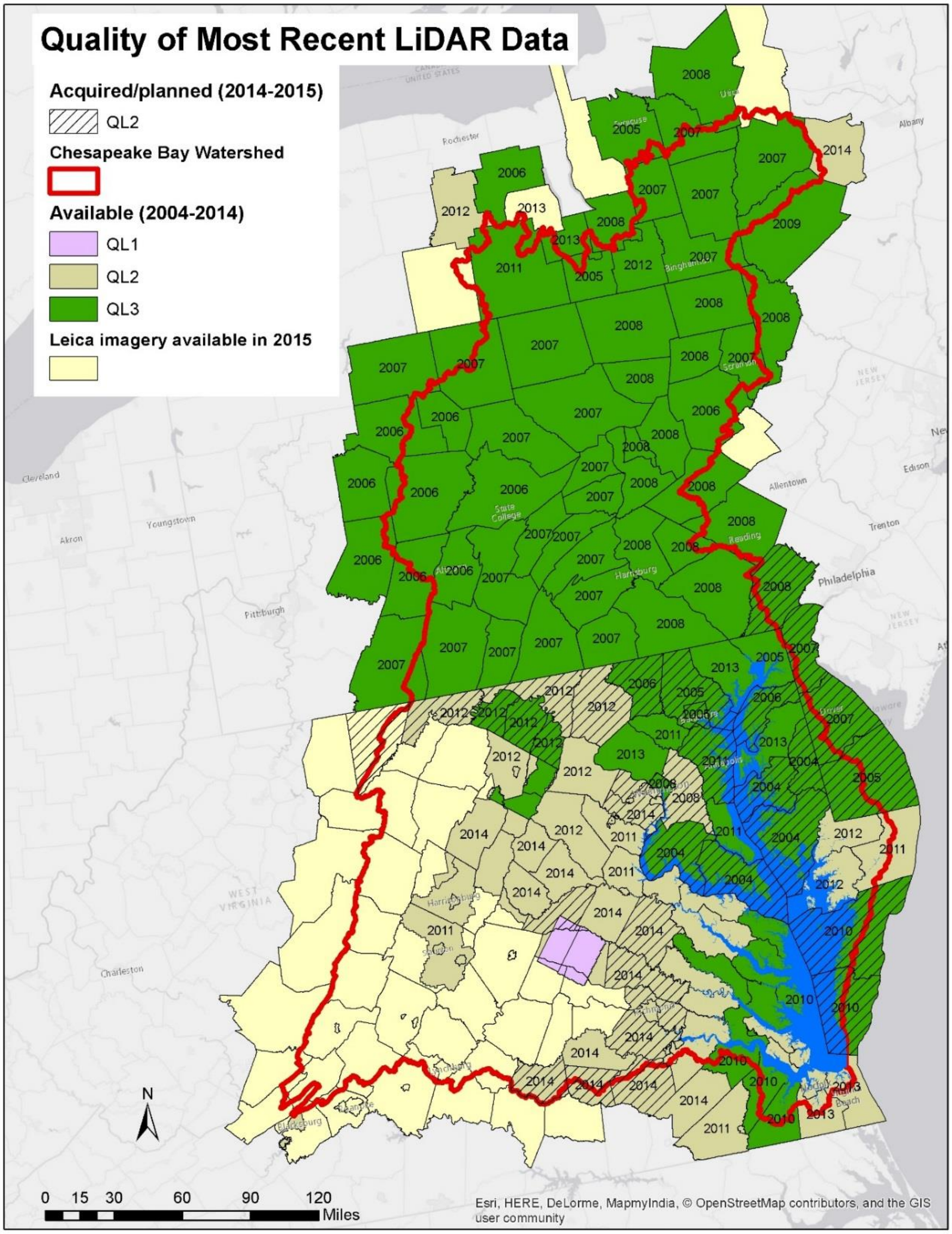

Figure 4. Current and planned availability of LiDAR data. QL1-3 refer to data Quality Levels that influence the spatial resolution and accuracy of the final product (e.g., QL-2 = 2 points per m^2 with 9.25 cm vertical RMSEz; and QL-3 = 0.25 – 1 point per m^2 with 18.5 cm vertical RMSEz).