LAND USE METHODS AND METRICS OUTCOME

1. What lessons have you learned over the past two years of implementation?

The past two years have been focused on developing high-resolution (1-meter) land cover and land use data for 2017, identifying hot spots of change with Landsat satellite data, and accurate, complete detection of land cover change from 2013 to 2017. While all watershed counties will eventually be included in this analysis, initial work over the past two years has focused on a subset of counties due to workload constraints and lack of LiDAR imagery throughout the watershed. The development of these data has forced a rethinking of the original monitoring and impact assessment objectives outlined in the Logic and Action Plan. Below are brief notes outlining this rethinking for each action.

Management Approach 1: Monitor the rate of conversion of forests, wetlands, and farmland, (and the rate of impervious surface change).

1.1 Design and implement a manual, stratified sampling approach at the county level and assess land cover change from high resolution imagery circa 2009-2013.

- Progress: This project was initiated back in 2014 but stalled due to lack of staff support and knowledge of the impending of wall-to-wall high-resolution land cover and land use change datasets.
- Lessons Learned/Confirmed: Sampling land cover/use change with high-resolution data is not necessary when complete wall-to-wall datasets are available. No sense in attempting to sample change given plans to produce wall-to-wall change datasets.

1.2 Assess land use change throughout the Bay Watershed and Bay States from the early 1980's through mid-2010's using the CBP 2013 high-res land use coupled with the Land Change Analysis and Monitoring Program Database and National Land Cover Database, the NRCS National Resources Inventory, and the USFS's Forest Inventory and Assessment data.

- Progress: This has partly been accomplished. Land use change throughout the watershed has been assessed at moderate resolution (30-meter) using the 2016 National Land Cover Database, the National Wall-to-Wall Anthropogenic Land Cover Dataset, and the National Land Use Dataset over multiple time periods spanning the mid 1970's to 2016. Work on backcasting the high-resolution land use from 2013 to the mid-1980's at the parcel scale has begun with an initial focus on deconstructing the urban footprint.
- Lessons Learned/Confirmed: Land use/cover datasets derived from Landsat satellite imagery is not able to consistently detect low density development and only detects the impervious surface portions of such development. Low-density residential development is under-represented in the NLCD and over-represented in the NWALT and NLUD

datasets that rely on ancillary data, such as population or housing density, to detect residential land use. The implications can be profound when examining the impacts of land conversion on water quality because the NLCD depicts development mostly on farmland whereas the NWALT and NLUD indicate that forests are mostly impacted. Backcasting the high-resolution data is very challenging but could provide a much more accurate depiction of land conversion rates than anything currently available.

1.3 Assess difference in high resolution land cover maps at the County level.

- Progress: High-res land cover was acquired for Prince George's county for the years 2009 and 2013. While both datasets were produced by the University of Vermont, they were not easily comparable because they were produced using slightly different algorithms that were optimized for the data and techniques available at the time of production. Attempts were made to smooth the data so that they could be compared but the results were still overwhelmed by false change.
- Lessons Learned/Confirmed: Change detection has to be a specified objective at the outset of developing high-resolution data products as it is in the EPA's Cooperative Agreement with the Chesapeake Conservancy to produce comparable data for 2013, 2017, and 2021.

1.4 Investigate options for monitoring "hot spots" of land change every two years

- Progress: This was accomplished for several states in preparation for the 2019 milestone updates but proved resource intensive because it is largely a manual production effort that was diverting resources from producing the complete wall-to-wall land cover change products.
- Lessons Learned/Confirmed: Comparisons of hot spots of tree canopy change with initial wall-to-wall tree canopy change products available for several Maryland counties illustrated the level of omissions (missed change) in the hot spot data. Comparisons of the NLCD change product for hot spot detection where the high-resolution hot spot data were unavailable illustrated significant (2x – 3x) differences, challenging the accuracy of the NLCD change products for informing the milestone updates (they were not used).

1.5 Monitor "hot spots" of change

- Progress: Note yet attempted.
- Lessons/Learned/Confirmed: No sense doing this given lessons learned in trying to produce the hot spot data (see 1.4)

1.6 Map and ReMap High-res land cover/use: 2013/14; 2017/18; 2021/22

- Progress: High-resolution 2017 land cover data have been produced for 53 counties as of December 8, 2020 https://cicgis.org/portal/apps/webappviewer/index.html?id=262ce838a60048e9a0f136d904639f66. The first draft of the 2017 land cover and land use data will be produced for all 206 counties by June 30th, 2021 including revisions to the 2013 land cover and land use data. The final, publicly available version of the 2017 data and revised 2013 data will be available by December 2021- the deadline for this Outcome. The complete land use/cover data for all three epochs will be complete in the latter part of 2023 or early 2024.

- Lessons Learned/Confirmed: Producing comparable land cover products for 2013 and 2017 based on existing data requires a somewhat custom approach for each county based on the type, quality, and vintage of ancillary data (e.g., planimetric impervious cover, leaf-off imagery, LiDAR normalized Digital Surface Models). In addition, no product can achieve the targeted level of accuracy (90-95%) without significant manual editing. This is particularly true for change because change is rare so a few large-area omissions could result in highly inaccurate results. Purchasing high-resolution imagery for 2021 and future years from Hexagon or Vexcel should be explored because both companies provide a digital surface model (elevation of the tops of things) with their imagery allowing for more accurate temporal representation (LiDAR is often +/- 3 or more years from the dates of the NAIP imagery) and higher quality spectral data may further reduce the need for and cost of manual editing.

Management Approach 2: Quantify the impacts of land conversion on water quality, healthy watersheds, and communities.

2.1 Quantify impact of land conversion on water quality (explaining changes in nutrient and sediment that relate to monitored and modeled land conversion).

- Progress: This objective has been achieved to the extent practicable. The 2013 high-resolution land use and Chesapeake Bay Land Change Model informed the Phase III WIPs and were used to inform the 2019 Milestones. Work is on track to provide the 2017 land use and revised 2013 land use to inform the 2021 Milestones and a retrospective “backcast” of land use from 2013 to 1985 is under development.
- Lessons Learned/Confirmed: Streamlining and operationalizing the production of land use data (past, present, and future) is needed to minimize costs and provide timely land change information to inform CBP outcomes and needs. Using the CBP watershed model, e.g., CAST, to assess the relationship between water quality and land use can be misleading. CAST currently integrates the Census of Agriculture with the high-res land use data resulting in some illogical transitions. Moreover, CAST integrates rainfall patterns, BMPs, land-to-water delivery factors, and instream factors when estimating changes to loads over time, further confounding the relationship between land use and water quality. Pollutant loading coefficients, derived from CAST, may provide the most intuitive way of understanding the water quality implications of land use change.

2.2 Quantify impact of land conversion on healthy watersheds, wildlife, and stream habitats.

- Progress: The Chesapeake Healthy Watersheds Assessment (v1.0) has been released and relies on many metrics related to land use/cover conditions. These will be updated with the 2017 high-res land use dataset once that is available. In addition, the new 2017 land use dataset and revised 2013 land use dataset include ~55 classes compared to the original 13 classes in the initial 2013 land use dataset. Urbanization has been forecast through 2055 for the entire watershed and an associated vulnerability metric has been drafted. No progress has been made in identifying habitat metrics aside from the enhanced detection and classification of potential wetlands which will be produced for the entire watershed by December 2021.
- Lessons Learned/Confirmed: While a 13-class dataset is sufficient to inform the Bay TMDL it is not sufficient for communicating and understanding land use/cover change as depicted in high-resolution datasets. This is because the high-resolution data coupled with ancillary information are able detect a variety of change phenomena that could confound interpretation of the data for habitat and healthy watershed outcomes. For

example, tree fall gaps due to natural causes or timber harvests contribute to reductions in tree canopy but may not warrant a management response compared to tree loss due urban development and other practices.

2.3 Quantify impact of land conversion on communities.

- Progress: No direct progress has been accomplished mainly because the term “communities” has not been defined and community concerns/needs not solicited. However, there is potential to work with the Diversity workgroup and Climate Resiliency Workgroup to identify underserved communities and communities at risk. There is also potential to outreach to communities in healthy watersheds on the impacts of land use change and leverage efforts to conserve 30% of the watershed by 2030 to incentivize conservation efforts around certain communities.
- Lessons Learned/Confirmed: Need leadership and interest in this component of the outcome for it be accomplished.

Management Approach 3: Communicate the results to the public, elected officials, and to the Bay Program.

3.1 Link the results of the Land Use Methods and Metrics and Land Use Options Evaluation Outcomes.

- Progress: This possibility has been discussed at length by the coordinators of the Healthy Watersheds GIT and Land Use Workgroup. It makes sense that the information generated under the LUMM outcome support actions specified in the LUOE outcome. Translators (preferably paid) are needed to communicate the information from both outcomes to groups with vested interests in it.
- Lessons Learned/Confirmed: A strategy is needed to communicate land change information to the public and local officials coupled with suggested actions and resources.

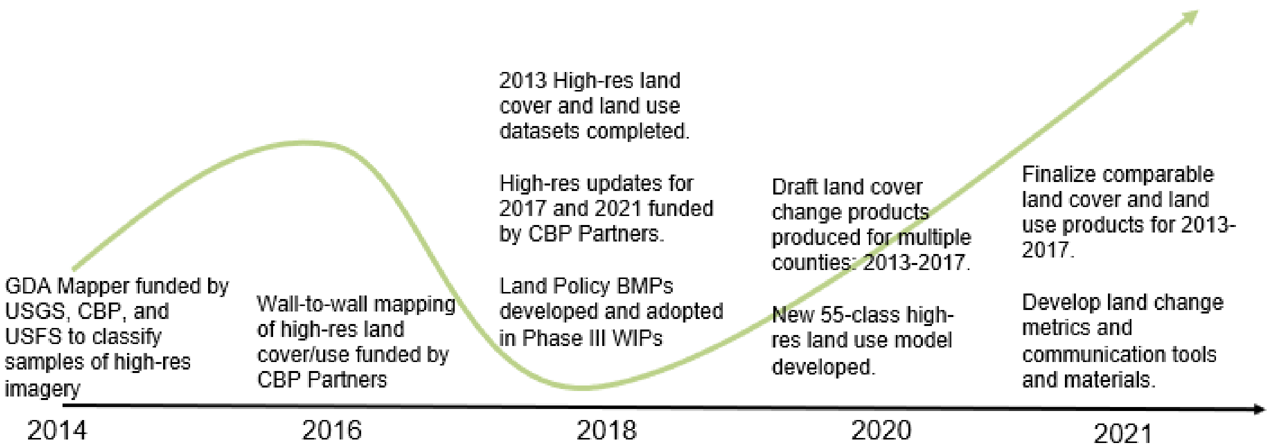
3.2 Develop a Chesapeake Bay Land Change website.

- Progress: A storymap is underdevelopment to illustrate changes in land use/cover. In addition, the USFS is working on producing automated tree canopy fact sheets for communities to help them understand the value of tree canopy, how it is changing and why, and what can be done to maintain/increase tree canopy.
- Lessons Learned/Confirmed: The impacts of land use/cover change are so broad and touch on so many different outcomes that separate communication strategies could/should be developed for each.

2 Are making progress at a rate that is necessary to achieve the outcome you are working toward.

Most of the Outcome objectives are on track for initial completion by December 2021, the deadline for this outcome. Assessing wetland change is technically not possible given the outdated inventory of non-tidal wetlands and our inability to monitor sub-surface changes in hydrology that impact wetlands. The impacts of land change on communities could be accomplished if a group assumes responsibility for that part of the Outcome.

During the 2019 SRS review, the deadline for this Outcome was extended from it’s original 2016 date to 2021. However, the purpose of this Outcome is to monitor land change and to assess impacts from those changes which requires a longer duration of monitoring to achieve. The CBP Partners need to decide if this is a one-and-done effort or if it marks the start of longer-term land monitoring program.



3 What scientific, fiscal and policy-related developments will influence your work over the next two years?

- Federal agency policies and regulations related to climate change
- CBP Partner commitments to conserving 30% of land by 2030 and/or 50% by 2050
- Development of an effective CBP local engagement strategy
- Increased affordability of high-resolution satellite spectral data
- Increased affordability and precision of LiDAR imagery
- Advancements in artificial intelligence for mapping and predicting land use/cover conditions and change.
- Increased understanding of the role of landscape context in estimating BMP efficiencies and land use pollutant loads
- CBP Partner uses and interest in the high-resolution land use/cover products

The technological advancements discussed above will not be realized before the official conclusion of this Outcome in December 2021 however shifting agency commitments over the coming year will potentially heighten interest and application of this Outcome to state and county-level climate adaptation and mitigation strategies. Increased affordability and capability of satellite and airborne imagery will increase the temporal precision and accuracy of the CBP's estimates of land conversion rates, advance our understanding of the causes and consequences of land use change, and decrease the cost and time of data creation. which will inform our strategies and policies for mitigating negative environmental effects. Advancements in technology and science combined with a greater understanding of land change and its consequences will inform the CBP's decision whether to continue monitoring land use/cover change at high-resolution following conclusion of the Cooperative Agreement with the Chesapeake Conservancy. The perceived value of this Outcome will largely determine the value of continued high-resolution land use monitoring.

4 Based on your response to the questions above, how will your work change over the next two years?

- The full automation of land use production will reduce the cost of developing these data in the future. Full automation is planned for spring of 2021. Production of land cover cannot be fully automated at this time although advancements in artificial intelligence and machine learning show promise and could reveal new classification opportunities- for example- mapping all animal operations in the watershed.
- Communication products may also be fully automated, enabling any municipality or county to automatically generate fact sheets with land use change statistics and interpretations specific to their jurisdiction.
- Objective measures of success in informing local decisions with the data produced by this outcome will be pursued. Such measures might include the number of website visits, data downloads, citations. More importantly, though, is direct evidence that the land characterization and change data are being used in public awareness campaigns, policies, or legislation. To achieve this level of success, translators of the data and metrics are need to communicate with and between subject matter experts and targeted stakeholder groups.

5 What, if any, actions can the Management Board take to help ensure success in achieving your outcome?

- Support re-soliciting a Cooperative Agreement to monitor land use/cover change every 4-5 years through 2030 (e.g., adding 2025/26 and 2029/30 dates) and institutionalizing high-res land cover/use monitoring in the Bay watershed.

- Support integrating this outcome with the Land Use Options Evaluation and Local Leadership Outcomes, and with the CBP's Local Engagement Strategy to help ensure that data are used to inform land use planning and land conservation decisions.
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  - Support the need for funded translators to bridge the gap between the data and local land use and conservation decisions.

If high-resolution monitoring of land cover and land use discontinues, the CBP Partners will only have data spanning an eight-year period which happens to correspond to a period with slow economic growth. A better understanding of how the land changes is critical to assess progress towards the TMDL and other goals in addition to serving as the foundation for future watershed and land change model calibration and parameterization. A longer monitoring-period is needed to better capture the breadth of phenomena that impacts water quality, watersheds, and communities. Continued technological advancements hold promise to reduce the costs and improve the quality of land change monitoring.