Joint LCMS/LCMAP Response Design – V1.1 (16 Oct 2015)

**Introduction**

This document describes the approach (or response design) for using the plot-based TimeSync time series visualization tool to collect reference information for the joint LCMS/LCMAP effort to comprehensively map land cover and land use change across the US using the Landsat data record from 1984-present. For any given plot, TimeSync is used to temporally demarcate Landsat spectral trajectories into observable change segments, following the logic of Cohen et al. (2010) and Kennedy et al. (2010). Segments are approximately linear spectral trends commonly associated with vegetation disturbance and regrowth processes, and may involve only land cover change or both land cover and land use change. Vertices define start and end dates of a given segment and have descriptors that characterize both the land use and land cover before and after a change event.

A disturbance in a woody vegetation environment is commonly declared only in cases where the woody vegetation is affected. Occasional snow cover or recurring inundation of wetland areas that does not significantly alter the longer-term trajectory of shrubs and trees are not considered disturbances. Disturbances in non-forest environments are possible, such as grassland fires or mechanical removal of vegetation in shrub dominated systems. Disturbances are also declared for land use changes (e.g., agricultural land transformed into a housing development), and are labeled as conversion. Regrowth is a change process that involves vegetation growth, commonly associated with post-disturbance vegetation succession but also with accumulation of vegetation in areas where growth was previously inhibited. Integrated data can yield additional information that is not readily apparent from the individual interpretation elements. In such cases, combining that change process with before and after land use, however, does resolve this.

The response design is not static, and this document will be updated as necessary. It is important to document challenges, inconsistencies, or other remarkable situations that arise during the interpretations. Regular meetings among interpreters and other critical players will take place (beginning monthly) to discuss these challenging observations and resolve them.

How the response design works?

The joint LCMS/LCMAP design requires selections from several categories: Land Use, Dominant (Area-based) Land Cover Element, Change Process, and Checkboxes (if relevant). Several rules must be adhered to:

1. *All calls are explicitly based on the 1-pixel plot area*. However, it is important to view the 9-pixel neighborhood centered on the 1-pixel plot and the temporal context to make the calls.
2. *The dominant use and process must be chosen, based on areal coverage in the 1-pixel plot*.If there are secondary use or process classes, those are ignored, but should be documented in the comments box. Forest is a special case, in that it must meet a minimum size threshold.
3. *Checkboxes must be used if they are relevant*. Where there are multiple checkboxes, more than one can be chosen. In some cases, the checkboxes are mutually exclusive, in other cases they are not. This should be obvious from the context.
4. *The dominant cover element must be chosen.* But if other cover elements exist (must be at least 10% of pixel), those are noted with checkboxes.
5. *There is an implied hierarchy in the Land use class structure*. Forest is chosen before before Rangeland before Non-forest wetland; other classes are naturally mutually exclusive.
6. *Land use class Other is for snow/ice, water, salt flats and other unlisted use types.*
7. *The change process class Other is an option for disturbance processes*. However, this should be rarely used, and only when there is certainty about disturbance but uncertainty about cause.
8. *There are two site-prep fire checkboxes*. The one under fire is used when the site-prep fire results in a separate, distinguishable disturbance segment, whereas the one under harvest is used when only the site-prep fire is seen but we also want to capture the harvest event preceding it.

**Vertex Labels: Land Use**

* **Forest** – planted or naturally vegetated land which contains (or is likely to contain) 10% or greater tree cover at some time during a near-term successional sequence. This may include deciduous, evergreen and/or mixed categories of natural forest, forest plantations, and woody wetlands. In accordance with FIA’s definition of forest, trees (or the ground area with potential for trees) must be a minimum of 1 acre in size (i.e. approximately >= 5 contiguous Landsat pixels) and at least 120 feet wide (i.e. approximately 1 Landsat pixel). Patches of 5 or more adjoining pixels can take any shape including linear. Forest roads (i.e. those that are not used for public transport from town to town), are considered forestland use. For situations where trees occur around a home site (or other man-made structure) or in an agricultural field, the land use call will revert to developed or agriculture respectively. Rivers and streams that are overtopped by trees are considered forest land use. Actively managed tree farms, orchards and vineyards are considered agriculture.
  + - In the event a plot meets the minimum tree cover and patch size threshold for forest use but is also determined to be a **Wetland**, then a check box will be used to indicate this secondary use class.
* **Developed** – Areas of intensive use such that any portion of the pixel is covered with structures (e.g. high density residential, commercial, industrial, or transportation), or less intensive uses where the land cover matrix includes both vegetation and structures (e.g., low density residential, lawns, recreational facilities, cemeteries, transportation and utility corridors, etc.), including any land functionally altered by human activity. Note that narrower forest and agricultural roads are considered forest or agricultural land use respectively.
  + - In the event that strip mining, open-pit mining, quarries, or mountain top removal is observed a check box will be used to indicate the presence of **Mining** activity.
* **Agriculture** – Land in either a vegetated or unvegetated state used for the production of food, fiber and fuels. This includes but is not limited to cultivated and uncultivated croplands, hay lands, actively managed and/or grazed pasture lands, orchards, vineyards, confined livestock operations, and areas planted for production of fruits, nuts or berries. Roads used primarily for agricultural use (i.e. not used for public transport from town to town) are considered as agriculture land use.
  + - In an effort to better distinguish food production from managed pasture and hay lands specific evidence of **Row crops** and the presence of **Orchard/Tree farms/Vineyards** will be recorded with a series of check boxes.
* **Non-forest Wetland** – Lands where water saturation (either permanently or seasonally) is a primary factor in determining soil characteristics, vegetation types, and animal communities. Examples include marshes, bogs, swamps, quagmires, muskegs, sloughs, fens, and bayous.
* **Rangeland** – Lands where the native vegetation is predominately grasses, grass-like plants, forbs or shrubs suitable for grazing or browsing of livestock or other animals. This category does not include pasture directly associated with agriculture, but does include open rangeland in which vegetation is not being actively managed (although it may be grazed). Most rangeland in the U.S. is located west of an irregular north/south line that cuts through the Dakotas, Nebraska, Kansas, Oklahoma and Texas. In the arid regions of the western U.S. care should be taken to ensure oak woodlands and pinyon-juniper dominated systems that meet the minimum tree cover and patch size thresholds are classified as forest land use.
* **Other** – Lands which are perennially covered with snow and ice, water, salt flats and other undeclared classes. Glaciers and ice sheets or places where snow and ice obscure any other land cover call are included (assumed is the presence of permanent snow and ice; otherwise a different class is more appropriate). Water includes rivers, streams, canals, ponds, lakes, reservoirs, bays, or oceans. This assumes permanent water (which can be in some state of flux due to ephemeral changes brought on by climate or man); otherwise a different class is more appropriate.

**Vertex Labels: Dominant Land Cover Element**

* **Tree** – Land where the cover of live or standing dead trees is greater than or equal to 10% of the pixel area.
* **Shrub** – Vegetated land where shrub cover is greater than or equal to 10% and tree cover is less than 10% of the pixel area.
* **Grass/forb/herb** – Land predominately covered with perennial grasses, forbs, or other forms of herbaceous vegetation. The non-grass cover component (e.g. shrubs and trees) comprises less than 10% of the pixel area.
* **Impervious** – Land covered with man-made materials that water cannot penetrate, such as paved roads, rooftops, and parking lots.
* **Natural Barren** – Land comprised of natural occurrences of bare soil associated with rotational croplands, and perennially barren areas such as deserts, playas, rock outcroppings (including minerals and other geologic materials exposed by surface mining activities), sand dunes, salt flats, and beaches where less than 10% of the pixel area is vegetated.
* **Snow/Ice** – Land where at least 10% of the pixel area is covered by permanent snow and ice.
* **Water** – Land where at least 10% of the pixel area is covered by permanent water.

**Segment Labels: Change Processes**

* **Fire** – Land (regardless of use) altered by fire, regardless of the cause of the ignition (natural or anthropogenic), severity, or land use.
  + - A check box will be used to capture the occurrence of post-harvest **Site-prep fires** which result in a separate, distinguishable disturbance segment. For instances where burning is evident but the preceding harvest is not, the site-prep fire option under harvest should be used instead. Checkboxes also exist to distinguish between natural and prescribed burning.
* **Harvest** – Land where trees, shrubs or other vegetation have been mechanically severed or removed by anthropogenic means. Examples include salvage logging after fire or insect outbreaks, scraping, chaining, earth moving, mining, building of non-forest roads, dams, and building or construction of man-made structures. Harvests can occur over a two-year (or more) period, but should only be assigned a single, multi-year segment. For example, some systems are managed such that a few trees are removed over the course of several consecutive years, and in this case it is best to declare a single, multi-year harvest segment.
  + - A series of check boxes will be used to record evidence of **Clearcutting** (defined as >=80% removal of trees/vegetation), **Thinning** (defined as <=20% removal of trees/vegetation), and **Site-prep fires** (e.g. where vegetation and debris remaining after clearcutting is burned to ready the site for planting). Note this site-prep fire option is used only in circumstances where burning is evident, but the preceding harvest is not directly seen due to image acquisition timing or cloud cover obstruction. In the event a site-prep fire results in a separate, distinguishable change segment, the site-prep fire option under fire should be used instead.
* **Decline** – Land altered by disturbance from non-anthropogenic or non-mechanical means. This type of stress related disturbance often results in a subtle spectral trend in natural (primarily woody) vegetation environments, most likely from insects, disease, drought, acid rain, etc. Clear evidence of tree mortality and/or loss of leaf area must be observed.
* **Wind** – Land (regardless of use) where vegetation is altered by wind related damage from hurricanes, tornados, and storms.
* **Hydrology** – Land where flooding has significantly altered woody cover or other land cover elements regardless of land use (e.g. new mixtures of gravel and vegetation in and around streambeds after a flood). Flood disturbances with a clear effect on forest health or which induce a prolonged recovery period should also be included, whereas floods that only affect the understory and recover within a year or two would be considered ephemeral.
  + - Check boxes are used to record specific evidence of **Flooding** and **Reservoir/Lake water fluxuations** (which include swampy areas or lake/reservoir edges which rise and fall due to changes in climate or management; in the event water levels are highly variable year-to-year the ephemeral checkbox should also be used).
* **Debris** – Land (regardless of use) altered by natural material movement associated with landslides, avalanches, volcanos, etc.
* **Growth/Recovery** – Land exhibiting an increase in vegetation cover due to growth and succession over three or more years. Applicable to any areas that may express spectral change associated with vegetation regrowth. This includes vegetation growth from bare ground, as well as the over topping of intermediate and co-dominate trees and/or lower-lying grasses and shrubs.
* **Stable** – Where no significant change is evident in the spectral response and the trend is essentially flat. Agricultural systems and wetlands are commonly highly variable spectrally through time, and are thus considered stable but ephemeral.
* **Conversion** – Land by which mechanical or other change mechanisms lead to a transformation of land from one use category to another. Examples include but are not limited to deforestation (e.g. loss of forest to other non-forest uses), afforestation (e.g. establishment of trees in a previously non-forested area), urbanization (e.g. agricultural land cleared for residential development), and agricultural expansion (e.g. grassland tilled for agricultural use). A check box will be used to record evidence of **Wetland drainage**, where removal of water from low-lying areas, often near coastal zones, results in a shift from wetland to some other land use (e.g. agricultural, recreation or housing).
* **Other** – Land (regardless of use) where the spectral trend or other supporting evidence suggests a disturbance or change event has occurred but the definitive cause cannot be determined or the type of change fails to meet any of the change process categories defined above. The comment field in TimeSync should be used to further describe the situation encountered.

**References**

Cohen, W.B., Z. Yang, and R.E. Kennedy. 2010. Detecting trends in forest disturbance and recovery using yearly Landsat time series: 2. TimeSync - Tools for calibration and validation, *Remote Sensing of Environment* 114:2911-2924.

Kennedy, R.E., Z. Yang, and W.B. Cohen. 2010. Detecting trends in forest disturbance and recovery using yearly Landsat time series: 1. LandTrendr - Temporal segmentation algorithms, *Remote Sensing of Environment* 114:2897-2910.