LANDSAT
BURNED AREA (BA)
PRODUCT GUIDE

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Approved By:

KAREN ZANTER

K. Zanter
LSDS CCB Chair
USGS

EROS
Sioux Falls, South Dakota
Executive Summary

This document describes relevant characteristics of the Landsat Level 3 Burned Area (BA) Science Product to facilitate its use in the land remote sensing community.

Landsat Level 3 Science Products are derived from U.S. Landsat Analysis Ready Data (ARD). U.S. Landsat ARD consist of the most geometrically accurate Landsat 4-5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Landsat 8 Operational Land Imager (OLI) / Thermal Infrared Sensor (TIRS) data that are consistently processed to the highest scientific standards and level of processing required for direct use in monitoring and assessing landscape change. Additional information specific to U.S. Landsat ARD product characteristics is located on the Landsat Missions Web Site.
## Document History

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<th>Document Number</th>
<th>Document Version</th>
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<td>LSDS-1332</td>
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Section 1  Introduction

1.1  Background
Landsat satellite data have been produced, archived, and distributed by the U.S. Geological Survey (USGS) since 1972. Users rely upon these data for conducting historical studies of land surface change but have shouldered the burden of post-production processing to create applications-ready data sets. To alleviate this burden on the user, the USGS has initiated an effort to produce a collection of Landsat Science Products to support land surface change studies. These products include terrestrial variables such as Surface Reflectance (SR), Surface Temperature (ST), Burned Area (BA), Fractional Snow Covered Area (fSCA), and Dynamic Surface Water Extent (DSWE) that are suitable for monitoring, assessing, and predicting land surface change over time.

![Figure 1-1. Examples of Landsat SR (left) and BA (right) Images.](image)

In Figure 1-1, the images were derived from Landsat 5 Analysis Ready Data (ARD) Tile H006V010 of the Conterminous U.S. (CONUS), July 07, 2003.

1.2  Purpose and Scope
This guide describes the Landsat Level 3 BA Science Product. The Landsat BA product is generated from the U.S. Landsat ARD SR Product. U.S. Landsat ARD consist of the most geometrically accurate and consistently processed Landsat 4-5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Landsat 8 Operational Land Imager (OLI) / Thermal Infrared Sensor (TIRS) data.

The Landsat BA package contains two acquisition-based raster layers and a product metadata file. Section 4 details the BA product specifications.
The methodologies used in this algorithm are derived directly from work performed by Hawbaker et al. (2017). Please see the References section for more information.

1.3 Document Organization

This document contains the following sections:

- Section 1 provides an introduction.
- Section 2 provides caveats and constraints for the Burned Area (BA) product.
- Section 3 provides product packaging for the BA.
- Section 4 provides product characteristics for the BA.
- Section 5 provides product access for the BA.
- Section 6 provides citation information for the BA product.
- Section 7 provides user service information.
- Appendix A contains the default file characteristics for the BA product.
- Appendix B provides metadata fields for the BA product.
- Appendix C provides a list of acronyms.
Section 2  Caveats and Constraints

1. BA products are derived from available U.S. Landsat ARD SR products. SR products are generated using two algorithms, the Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS) for Landsat 4-7 and the Landsat Surface Reflectance Code (LaSRC) for Landsat 8. Occasionally, Landsat data cannot be processed to SR due to missing auxiliary data. More information pertaining to the auxiliary data characteristics is described in the LEDAPS and LaSRC Product Guides. Date ranges of missing auxiliary data are listed under “Caveats and Constraints” on the Landsat Surface Reflectance web page.

2. Unlike the standard Landsat Level 1 Worldwide Reference System (WRS) scenes in Universal Transverse Mercator (UTM) projection into which Landsat data have always been processed, U.S. Landsat ARD products are immediately processed to Albers Equal Area Conic (AEA) projection and divided into equal-sized tiles with static extents. Figure 2-1 illustrates how an ARD tile compares to WRS scenes. Three sets of AEA projection parameters and tile grid extents are used for Landsat ARD for the three distinct regions of the U.S., which consists of the CONUS, Alaska, and Hawaii. BA products are generated only for the CONUS. The Landsat ARD web page describes the use of AEA and tiling grids in more detail.

![Figure 2-1. WRS Scenes (left) and U.S. Landsat ARD Tiles (right)](image)

NOTE: WRS scenes (left) have always been the standard Landsat product size. U.S. ARD tiles (right) are created from Landsat data in AEA projection, divided into equal-sized areas.
3. U.S. Landsat ARD products are generated from the highest quality data in the Landsat Level 1 Collection 1 inventory structure. Landsat 4-7 Tier 1 (T1) and Landsat 8 T1 and Tier 2 (T2) scenes are processed to ARD. Newly acquired scenes in the Collection archive are given a Real-Time (RT) designation. These newly acquired data are not processed to ARD until radiometric and geometric parameters are finalized and reprocessed into their appropriate Tier (~26 days for Landsat 7 and ~15 days for Landsat 8 after acquisition).

4. Landsat 7 ETM+ inputs are not gap-filled in SR production; therefore, gapped areas are not processed for SR. See the Landsat 7 web page for information on Landsat 7 Scan Line Corrector-off (SLC-off) data products.

5. Efficacy of the SR correction is likely to be reduced in areas where atmospheric correction is affected by adverse conditions:
   a. Hyper-arid or snow-covered regions.
   b. Low sun angle conditions.
   c. Coastal regions where land area is small relative to adjacent water.
   d. Areas with extensive cloud contamination.
   e. Users are cautioned against correcting data acquired over high latitudes (> 65°).

Refer to the SR Quality Assessment (QA) bands for pixel-level condition and validity flags.

6. Additional details pertaining to SR data products are found in the LEDAPS Product Guide and LaSRC Product Guide.

7. A QA process was applied to the BA products prior to release. This process visually assessed each scene-level BA product for excessive commission errors caused by incorrect cloud masks, poor georeferencing, or other reasons. Therefore, while the majority of Landsat scenes were used to generate the BA products, certain scenes may have been removed prior to final product generation.

8. Some burned areas are occasionally flagged as water in BA products. If the input Level 2 Pixel QA (PIXELQA) band has flagged a pixel as “water, terrain, low-confidence cloud”, it is flagged as water in the Burn Classification (BC) and Burn Probability (BP) bands of the BA product. This usually happens when there are terrain shadows within the burned area.

9. The Extensible Markup Language (XML) file lists the band information for both the BP and BC. The units for the pixel size is “m” and should be “meters” to be compliant with the schema.
Section 3  Product Packaging

This product guide is specific to the Landsat Level 3 BA Science Product. Details of other Landsat Science Products are covered in separate product guides.

3.1 Package Filename

All BA products are delivered in tar packages (.tar) specific to individual U.S. Landsat ARD tiles. The package filenames are structured similar to the original ARD tile identifiers (IDs), appended with the BA package name suffix. The following is an example of a typical BA package filename:

\[ \text{LXSS\_US\_HHHVVV\_YYYYMMDD\_yyyyymmdd\_CCC\_VVV\_PACKAGE.tar} \]

(e.g. LT05\_CU\_002006\_19920904\_20170915\_C01\_V01\_BA.tar)

- L: Landsat
- X: Sensor ("C" = OLI/TIRS, "E" = ETM+, "T" = TM)
- SS: Satellite ("08" = Landsat 8, "07" = Landsat 7, "05" = Landsat 5, "04" = Landsat 4)
- US: Regional grid of the U.S. ("CU" = CONUS)
- HHH: Horizontal tile number
- VVV: Vertical tile number
- YYYY: Acquisition year
- MM: Acquisition month
- DD: Acquisition day
- yyyy: ARD tile Production year
- mm: ARD tile Production month
- dd: ARD tile Production day
- CCC: Level 1 Collection number ("C01", "C02", etc.)
- VVV: Analysis Ready Data (ARD) Version number ("V01", "V02", etc.)
- PACKAGE: Data package ("BA" = Burned Area package)

3.2 Product Filename

The BA.tar packages “untar” (unzip) into two individual Georeferenced Tagged Image File Format (GeoTIFF; .tif) raster files and an XML (.xml) metadata file. The two raster files include maximum BP and BC. Section 4 describes the products in more detail. The following is an example of a BA ARD tile product filename:

\[ \text{LXSS\_US\_HHHVVV\_YYYYMMDD\_yyyyymmdd\_CCC\_VVV\_PRODUCT.ext} \]

(e.g. LT05\_CU\_002006\_19920904\_20170915\_C01\_V01\_BC.tif)

- L: Landsat
- X: Sensor ("C" = OLI/TIRS, "E" = ETM+, "T" = TM)
- SS: Satellite ("08" = Landsat 8, "07" = Landsat 7, "05" = Landsat 5, "04" = Landsat 4)
- US: Regional grid of the U.S. ("CU" = CONUS)
- HHH: Horizontal tile number
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>VVV</td>
<td>Vertical tile number</td>
</tr>
<tr>
<td>YYYY</td>
<td>Acquisition year</td>
</tr>
<tr>
<td>MM</td>
<td>Acquisition month</td>
</tr>
<tr>
<td>DD</td>
<td>Acquisition day</td>
</tr>
<tr>
<td>yyyy</td>
<td>ARD tile Production year</td>
</tr>
<tr>
<td>mm</td>
<td>ARD tile Production day</td>
</tr>
<tr>
<td>dd</td>
<td>ARD tile Production day</td>
</tr>
<tr>
<td>CCC</td>
<td>Level-1 Collection number (&quot;C01&quot;, &quot;C02&quot;, …)</td>
</tr>
<tr>
<td>VVV</td>
<td>Analysis Ready Data (ARD) Version number (&quot;V01&quot;, &quot;V02&quot;)</td>
</tr>
<tr>
<td>PRODUCT</td>
<td>Data product (&quot;BP&quot; = maximum burn probability, &quot;BC&quot; = burn classification)</td>
</tr>
<tr>
<td>ext</td>
<td>File extension (&quot;.tif&quot; = GeoTIFF, &quot;.xml&quot; = Extensible Markup Language)</td>
</tr>
</tbody>
</table>
Section 4  Product Characteristics

All BA products are generated from U.S. Landsat ARD SR data. BA products are processed to 30-meter spatial resolution in AEA projection using the World Geodetic System 1984 (WGS84) datum and gridded to a common tiling scheme. Products are delivered in various file formats, including GeoTIFF files for all BA raster products and XML metadata files. Spatial reference information is embedded within the GeoTIFF files. BA products are available going back to 1984 for the CONUS.

4.1 Available Products
Available BA products include two raster layers and an .xml metadata file. 4.2 describes specifications for each output raster layer. BA Products include the following:

1. Burn Probability (BP) – Raster Layer: Provides the maximum per-pixel BP; generated by comparing the current individual acquisition against composites created from seasonal average and the previous year of acquisition.

2. Burn Classification (BC) – Raster Layer: Indicates if an area was burned by applying a threshold to the BP product.

3. Metadata – Includes tile-based and input scene-based information in .xml format.

4.2 Product Specifications
Table 4-1 describes the overall specifications for the BA products.

<table>
<thead>
<tr>
<th>Band Name</th>
<th>Description</th>
<th>Data Type</th>
<th>Units</th>
<th>Range</th>
<th>Valid Range</th>
<th>Fill Value</th>
<th>Saturate Value</th>
<th>Scale Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>tileID_BP</td>
<td>Burn Probability</td>
<td>UINT8</td>
<td>Percent / Flag</td>
<td>0-255</td>
<td>0-255</td>
<td>255</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>tileID_BC</td>
<td>Burn Classification</td>
<td>UINT8</td>
<td>Flag</td>
<td>0-255</td>
<td>0-255</td>
<td>255</td>
<td>NA</td>
<td>NA</td>
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</table>

Table 4-1. BA Product Overall Specifications

Table 4-2 and Table 4-3 describe the pixel value interpretations for the individual products.
<table>
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<th>Pixel Value</th>
<th>Interpretation</th>
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<tr>
<td>0</td>
<td>Not-burned</td>
</tr>
<tr>
<td>1</td>
<td>Burned</td>
</tr>
<tr>
<td>249</td>
<td>Extreme values mask</td>
</tr>
<tr>
<td>250</td>
<td>Extreme values mask</td>
</tr>
<tr>
<td>251</td>
<td>Water</td>
</tr>
<tr>
<td>252</td>
<td>Snow/Ice</td>
</tr>
<tr>
<td>253</td>
<td>Cloud</td>
</tr>
<tr>
<td>254</td>
<td>Cloud shadow</td>
</tr>
<tr>
<td>255</td>
<td>Fill</td>
</tr>
</tbody>
</table>

Table 4-3. BC Layer Pixel Values
Section 5  Product Access

Landsat Level 3 BA Science Products are accessible through EarthExplorer.
Section 6  Citation Information

There are no restrictions on the use of Landsat Science Products. It is not a requirement of data use, but the following citation may be used in publication or presentation materials to acknowledge the USGS as a data source and to credit the original research.

_Landsat Level 3 Burned Area (BA) Science Products courtesy of the U.S. Geological Survey._


Reprints or citations of papers or oral presentations based on USGS data are welcome to help the USGS stay informed of how data are being used. These can be sent to the contact information provided in Section 7.
Section 7  User Services

Landsat Science Products and associated interfaces are supported by USGS User Services staff at the USGS Earth Resources Observation and Science (EROS) Center. Questions or comments regarding Landsat Science Products or interfaces are welcomed through the Landsat “Contact Us” online correspondence form. E-mail can also be sent to the USGS User Services address with the same indication of topic.

    USGS User Services
    605-594-6151
    1-800-252-4547
    custserv@usgs.gov

User support is available Monday through Friday from 8:00 a.m. – 4:00 p.m. Central Time. Inquiries received outside of these hours are addressed during the next business day.
## Appendix A  Default File Characteristics

<table>
<thead>
<tr>
<th>Description</th>
<th>Example File Size (Kbytes)</th>
<th>Example File Name</th>
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<td>Maximum per-pixel burn probability</td>
<td>8,445</td>
<td>LC08_CU_011013_20170225_20171020_C01_V01_BP.tif</td>
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<tr>
<td>Indication of a burn based on applying a threshold to BP</td>
<td>228</td>
<td>LC08_CU_011013_20170225_20171020_C01_V01_BC.tif</td>
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<tr>
<td>Metadata</td>
<td>74</td>
<td>LC08_CU_011013_20170225_20171020_C01_V01_BA.xml</td>
</tr>
</tbody>
</table>

*BP = Burn Probability, BC = Burn Classification, TIF = Georeferenced Tagged Image File Format, XML = Extensible Markup Language

**Table A-1. Example of BA Product Files**
Appendix B  Metadata Fields

Example of BA tile global metadata:

```xml
<global_metadata>
  <data_provider>USGS/EROS</data_provider>
  <satellite>LANDSAT_8</satellite>
  <instrument>OLI/TIRS_Combined</instrument>
  <level1_collection>01</level1_collection>
  <ard_version>01</ard_version>
  <region>CU</region>
  <acquisition_date>2017-02-25</acquisition_date>
  <product_id>LC08_CU_011013_20170225_20171020_C01_V01</product_id>
  <production_date>2017-10-20T12:59:31Z</production_date>
  <bounding_coordinates>
    <west>-106.121484296</west>
    <east>-104.327813163</east>
    <north>35.0344346933</north>
    <south>33.5691340713</south>
  </bounding_coordinates>
  <projection_information datum="WGS84" projection="AEA" units="meters">
    <corner_point location="UL" x="-915585.000000" y="1364805.000000"/>
    <corner_point location="LR" x="-765585.000000" y="1214805.000000"/>
    <grid_origin>UL</grid_origin>
    <albers_proj_params>
      <standard_parallel1>29.500000</standard_parallel1>
      <standard_parallel2>45.500000</standard_parallel2>
      <central_meridian>-96.000000</central_meridian>
      <origin_latitude>23.000000</origin_latitude>
      <false_easting>0.000000</false_easting>
      <false_northing>0.000000</false_northing>
    </albers_proj_params>
  </projection_information>
  <orientation_angle>0.000000</orientation_angle>
  <tile_grid h="011" v="013"/>
  <scene_count>3</scene_count>
  <cloud_cover>0.1830</cloud_cover>
  <cloud_shadow>0.0844</cloud_shadow>
  <snow_ice>0.0634</snow_ice>
  <fill>37.1174</fill>
</global_metadata>
```

Example of BA tile band metadata:

```xml
<band category="image" data_type="UINT8" fill_value="255" name="BP" nlines="5000" nsamps="5000"
product="burned_area" source="sr_refl">
  <file_name>LC08_CU_011013_20170225_20171020_C01_V01_BP.tif</file_name>
  <short_name>LC08BP</short_name>
  <long_name>burn probability</long_name>
  <pixel_size units="m" x="30" y="30"/>
  <resample_method>none</resample_method>
  <data_units>percentage</data_units>
  <qa_description>
    0-100:Burn probability (%)
  </qa_description>
</band>
```
249-250: Extreme values mask
251: Water
252: Snow/ice
253: Clouds
254: Cloud shadows
255: Fill

</qa_description>

</band>

</qa_description>

</app_version>

<production_date>2018-03-21T12:00:00Z</production_date>

</band>

</qa_description>

</band>
## Appendix C  Acronyms

<table>
<thead>
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<th>Description</th>
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<td>AEA</td>
<td>Albers Equal Area</td>
</tr>
<tr>
<td>ARD</td>
<td>Analysis Ready Data</td>
</tr>
<tr>
<td>BA</td>
<td>Burned Area</td>
</tr>
<tr>
<td>BC</td>
<td>Burn Classification</td>
</tr>
<tr>
<td>BP</td>
<td>Burn Probability</td>
</tr>
<tr>
<td>CONUS</td>
<td>Conterminous United States</td>
</tr>
<tr>
<td>DSWE</td>
<td>Dynamic Surface Water Extent</td>
</tr>
<tr>
<td>EROS</td>
<td>Earth Resources Observation and Science</td>
</tr>
<tr>
<td>ETM+</td>
<td>Enhanced Thematic Mapper Plus</td>
</tr>
<tr>
<td>.ext</td>
<td>File Extension</td>
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<td>fSCA</td>
<td>Fractional Snow Covered Area</td>
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<td>ID</td>
<td>Identifier</td>
</tr>
<tr>
<td>LaSRC</td>
<td>Landsat Surface Reflectance Code</td>
</tr>
<tr>
<td>LEDAPS</td>
<td>Landsat Ecosystem Disturbance Adaptive Processing System</td>
</tr>
<tr>
<td>NA</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>OLI</td>
<td>Operational Land Imager</td>
</tr>
<tr>
<td>PIXELQA</td>
<td>Pixel Quality Assessment</td>
</tr>
<tr>
<td>QA</td>
<td>Quality Assessment</td>
</tr>
<tr>
<td>RT</td>
<td>Real-Time Tier</td>
</tr>
<tr>
<td>SLC</td>
<td>Scan Line Corrector</td>
</tr>
<tr>
<td>SR</td>
<td>Surface Reflectance</td>
</tr>
<tr>
<td>ST</td>
<td>Surface Temperature</td>
</tr>
<tr>
<td>TIRS</td>
<td>Thermal Infrared Sensor</td>
</tr>
<tr>
<td>TM</td>
<td>Thematic Mapper</td>
</tr>
<tr>
<td>.tar</td>
<td>Tape Archive – file extension</td>
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<tr>
<td>.tif</td>
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<tr>
<td>T1</td>
<td>Tier 1</td>
</tr>
<tr>
<td>T2</td>
<td>Tier 2</td>
</tr>
<tr>
<td>UINT</td>
<td>Unsigned Integer</td>
</tr>
<tr>
<td>USGS</td>
<td>U.S. Geological Survey</td>
</tr>
<tr>
<td>UTM</td>
<td>Universal Transverse Mercator</td>
</tr>
<tr>
<td>WGS84</td>
<td>World Geodetic System 1984</td>
</tr>
<tr>
<td>WRS</td>
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References


