Use of Polar Orbiting Earth Observatories to Create a Synoptic Inventory of North American Forested Areas Affected by Wildfire

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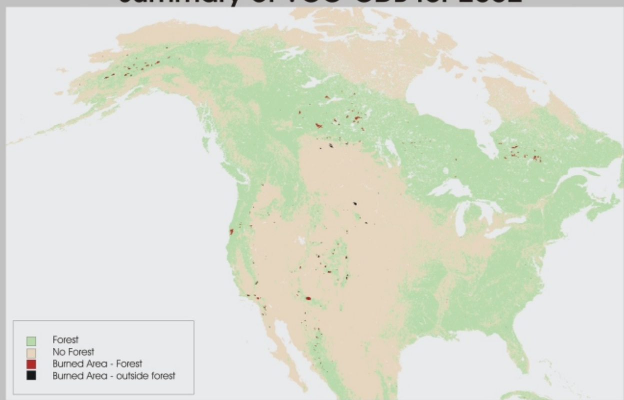
The Vegetative Cover Conversion product (VCC) is designed to be a global alarm product for rapid land cover change. VCC intends to locate change caused by deforestation, fire, and floods. Results shown here reflect the VCC results for "Change Due to Burning" (VCC-CDB).

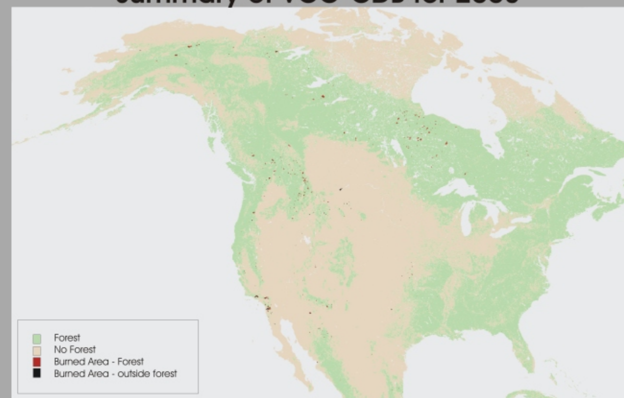
VCC-CDB is generated at 250m resolution using data from the MODIS instrument. 16-day composites are used to reduce the overall data volume and to yield the most cloud-free data set possible. Data are processed on a quarterly basis comparing data from the current year's quarter to the previous year's quarter. Normalized Burn Ratio (NBR) is calculated for each composite in each year using the formula (NIR - MIR)/(NIR + MIR) where NIR is near infra-red (MODIS band 2) and MIR is middle infra-red (MODIS band 7). Year 1 is subtracted from Year 2 to yield the differenced NBR (dNBR). As the dNBR value increases, the likelihood of the occurrence of burn increases (Key and Benson 2004). A threshold dNBR < 0.2 is used to delineate the lowest acceptable likelihood of burn occurrence. This threshold is intended to be conservative to avoid labeling areas that did not actually burn (errors of commission). With the dNBR values in hand, a mask is used to determine if the burn occurred in a forested area. The mask is derived from the MODIS Vegetation Continuous Fields percent tree cover product (Hansen et al 2003). Burns that occurred inside the mask are considered areas where change is possible. Outside of that mask change is considered less likely because the herbaceous ground cover will likely return quickly.

In the interest of avoiding errors of commission due to interannual differences in vegetation, the MODIS active fire product (MOD14) (NASA 2000) is used to seed the areas where burn is likely. From these seeds the dNBR threshold is used in an iterative process to allow the representation of the burn to grow to its natural boundary. This step attempts to capture the areas outside of the active fire product detections, that may have been obscured by bad data or burned between MODIS overpasses. The results for the MODIS VCC-CDB can be seen below.

Summary of VCC-CDB for 2002



Summary of VCC-CDB for 2003



Summary of VCC-CDB for 2004

MODIS VCC-CDB validation using USFS Burned Area Emergency Response (BAER) polygons

BAER fire polygons created by the USFS were used to validate the MODIS Vegetative Cover Conversion - Change Due to Burning (VCC-CDB) fire polygons. The validation was performed through a four step process: 1. Burned area as detected by the MODIS VCC-CDB algorithm were converted to shapefiles; 2. VCC-CDB polygons were aggregated to individual fire polygons; 3. Perimeter of BAER fires were used to validate the accuracy of VCC-CDB fire polygons by selecting for VCC-CDB polygons within 5 km of USFS BAER polygons; 4. Calculated the area of VCC-CDB inside and outside of USFS BAER fire polygons (Figures 3a,3b,3c, and Table 1).

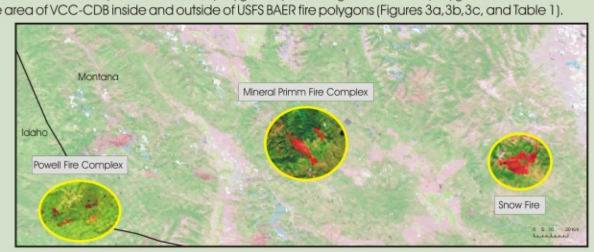


Figure 1a - USFS BAER Powell fire polygons.

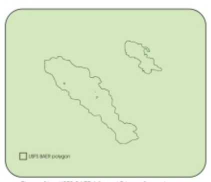


Figure 1b - USFS BAER Mineral Primm fire polygons.

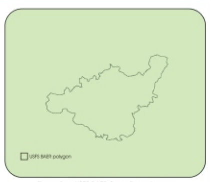


Figure 1c - USFS BAER Snow fire polygon.

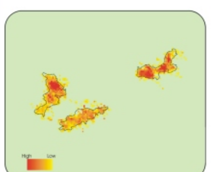


Figure 2a - MODIS VCC-CDB fire intensity (yellow = low while red = high), with USFS BAER Powell fire polygons.

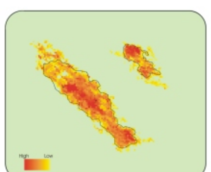


Figure 2b - MODIS VCC-CDB fire intensity (yellow = low while red = high), with USFS BAER Upper and Lower Mineral Primm fire polygons.

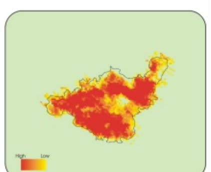


Figure 2c - MODIS VCC-CDB fire intensity (yellow = low while red = high), with USFS BAER Snow fire polygon.

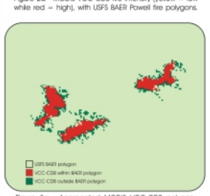


Figure 3a - Aggregated MODIS VCC-CDB polygon. Area in red represents VCC-CDB within the BAER polygon while the area in dark green is outside the BAER Powell fire polygons.

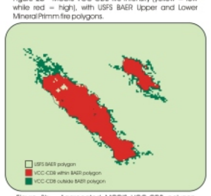


Figure 3b - Aggregated MODIS VCC-CDB polygon. Area in red represents VCC-CDB within the BAER polygon while the area in dark green are outside the BAER Powell fire polygons.

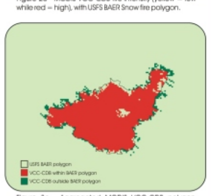


Figure 3c - Aggregated MODIS VCC-CDB polygon. Area in red represents VCC-CDB within the BAER polygon while the area in dark green is outside the BAER Snow fire polygon.

Table 1. Comparison of VCC-CDB and USFS BAER polygons. Statistics for each BAER polygon were calculated through the validation process described in the validation box (left). Fire polygons illustrated in validation box (left) are highlighted. Table is sorted in descending order of BAER polygon area.

Fire Name	Total BAER Acres	Total Area VCC	VCC Acres within BAER Polygon	VCC Acres outside BAER Polygon	% of BAER Polygon Area Covered by VCC Polygon
Oct 24 Complex #9	109,502	76,155	60,971	15,184	55.68%
BNB	91,268	104,309	80,749	23,560	88.47%
Aspen	81,981	81,591	69,614	11,977	84.91%
Fawn Peak	72,611	93,823	71,213	22,609	98.08%
Oct 24 Complex #3	59,889	12,781	11,727	1,054	19.58%
Snow	38,069	41,359	35,161	6,198	92.36%
Little Salmon Complex #2	30,815	40,035	25,044	14,991	81.27%
Little Salmon Complex #4	30,765	33,792	24,066	9,725	78.23%
Fish Creek	29,890	43,274	27,738	15,536	92.80%
Hot #6	29,804	29,143	25,551	3,592	85.73%
Wedge	27,268	51,753	25,575	26,178	93.79%
Cooney Ridge	26,362	29,081	23,102	5,979	87.63%
Lower Mineral Primm	19,953	27,645	19,028	8,617	95.37%
Robert	19,801	53,437	19,068	34,369	96.30%
Red Point	19,226	11,830	11,697	133	60.84%
Picture	15,428	11,707	11,484	223	74.44%
Oct 24 Complex #2	13,845	14,313	9,237	5,075	66.72%
Beaver	13,176	16,649	10,778	5,870	81.80%
Slims	12,197	9,807	8,904	903	73.00%
Sapp	11,551	15,357	10,111	5,246	87.54%
Little Salmon Complex #1	11,286	12,402	9,626	2,776	85.29%
Crazy Horse	8,869	13,683	8,665	5,018	97.70%
Black Mountain	7,950	8,649	7,115	1,534	89.49%
North Bighorn	7,858	8,880	6,696	2,185	85.22%
Oct 24 Complex #4	6,708	5,328	4,809	519	71.69%
Spanish	6,295	12,324	5,021	7,303	79.77%
Oct 24 Complex #1	6,077	2,363	1,904	459	31.32%
Oct 24 Complex #7	5,753	5,900	4,692	1,208	81.55%
Oct 24 Complex #10	5,688	5,869	4,409	1,460	77.52%
Lizard	5,570	1,158	1,158	1	20.78%
Gold	5,415	10,363	5,316	5,047	98.18%
Steeple	4,930	4,571	3,702	870	75.09%
Walker	4,836	1,961	1,777	184	36.75%
Togo Mountain	4,770	10,548	4,125	6,423	86.48%
Grindstone Complex # 7	4,728	6,795	4,135	2,660	87.47%
Oct 24 Complex #6	4,625	2,888	2,732	157	59.07%
Cherry Creek	4,221	5,606	3,881	1,725	91.95%
Mud	4,091	13,622	2,957	10,665	72.26%
Pleasant	3,887	5,297	3,585	1,713	92.21%
Upper Mineral Primm	3,878	6,378	3,725	2,654	96.06%
Little Salmon Complex #6	3,785	6,452	3,607	2,845	95.29%
East Table	3,558	7,398	3,193	4,204	89.74%
Powell Fire Complex #1	3,533	4,587	3,082	1,505	87.24%
Mrytle Creek	3,498	4,633	2,886	1,748	82.50%
Powell Fire Complex #3	3,445	4,819	3,021	1,797	87.70%
South Fork	3,424	7,676	3,373	4,303	98.49%
Oct 24 Complex #8	3,379	3,398	2,464	934	72.91%
Fish Lake	3,106	4,510	2,758	1,752	88.79%
Mormon	2,743	525	504	21	18.37%
Burnt Ridge	2,490	3,629	1,464	2,166	58.79%
Largo	2,308	1,807	1,573	233	68.17%
Moose	1,880	1,931	1,464	467	77.86%
Little Salmon Complex #5	1,777	7,629	1,677	5,952	94.37%
Gridstone Complex #3	1,528	1,514	465	1,049	30.43%
Total	**911,292**	**1,002,934**	**702,378**	**300,557**	**77.07%**

Conclusions

Total acres affected by wildfire have increased dramatically during the last decade. The long-term average is 4.3 million acres burned per annum, but in the last decade, annual burned acreage has exceeded 6 million acres in five of these years, with three of these having in excess of 8 million affected acres.

Accurate inventories of burn affected area and burn severity are critical to informing land management decisions and progress toward implementation of the National Fire Plan and the Healthy Forests Initiative.

The VCC-CDB approach described here has demonstrated the usefulness of moderate resolution remote sensing to provide synoptic information on wildfire effects in North America. A remote sensing approach has the advantage of providing continental scale inventory updates which are automated and internally consistent. When compared with in situ mapping of burned area at finer spatial resolution, the VCC-CDB method provides accuracies in excess of 90% for large fire events. The main variations in performance shown here result from two scenarios. For early season fires, data quality is an issue with persistent aerosols and clouds. For late season fires, insufficient post-fire data was utilized to capture post-fire effects and vegetation mortality. The former case is a limit of available data and will be represented by quality flags and confidence measures in an operational product. The latter case will be eliminated by ensuring that sufficient post-fire data is included in the analysis.

The moderate resolution VCC-CDB approach complements definitive mapping at finer resolution such as that provided by Landsat-type sensors. Moderate resolution results can be produced in near real-time, while definitive mapping as envisioned by the Monitoring Trends in Burn Severity (MTBS) program will lag by up to a year from the current fire season.

It is the recommendation of the authors that this approach be transitioned to the operational agencies for use in monitoring fire effects at a continental scale.

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Cartographic design and presentation by Karl Wurster