SUPPLEMENTARY MATERIAL

Sensitivity of optical satellites to estimate windthrow tree-mortality in a Central Amazon forest.

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**Appendix A**

In the windthrow affected area, large amounts of fallen trees piled on top of each other and additional crown debris made field work hazardous and made it impossible to count dead trees (Figure S1; Figure S2; Figure S3; Figure S4). Instead, we estimated the number of dead trees by subtracting the number of remaining living trees recorded in each subplot from 15, which represents the mean tree density of living trees in old-growth forests in our study region (~600 trees.ha-1), scaled to the size of our subplots (Table S1).

Árvore com galhos secos

Descrição gerada automaticamente com confiança média

Figure S1. General aspect of the windthrow affected area in November/2015.

Pessoas na floresta

Descrição gerada automaticamente

Figure S2. Delimitation of the central tracks of the forest inventory plots.

Pássaro em cima da árvore

Descrição gerada automaticamente

Figure S3. Delimitation of the central tracks of the forest inventory plots.

Pessoa andando na floresta

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Figure S4. Delimitation of the central tracks of the forest inventory plots.

Table S1. Reference data of density of trees in Terra Firme/Campinarana transition forest in Central Amazon. SD = Standard Deviation.

| **Vegetation type** | **Location** | **Density (trees.ha-1)** | **Reference** |
| --- | --- | --- | --- |
| Campina/Campinarana | Presidente Figueiredo-AM | 616 | [1] |
| Ancient fluvial terrace | Presidente Figueiredo-AM | 497 | [1] |
| Terra firme | Presidente Figueiredo-AM | 597 | [1] |
| Plate Forest (Terra Firme/Campinarana) | Manaus-AM | 477 | [2] |
| Forested Campinarana | Manaus-AM | 507 | [2] |
| Terra firme | São Gabriel da Cachoeira-AM | 523 | [3] |
| Terra firme | São Gabriel da Cachoeira-AM | 537 | [3] |
| Terra firme | São Gabriel da Cachoeira-AM | 505 | [3] |
| Terra firme | Igarapé Pamaáli (Içana)-AM | 614 | [3] |
| Forested Campinarana | São Gabriel da Cachoeira-AM | 547 | [3] |
| Forested Campinarana | São Gabriel da Cachoeira-AM | 642 | [3] |
| Forested Campinarana | São Gabriel da Cachoeira-AM | 611 | [3] |
| Forested Campinarana | Jandú-Cachoeira (Içana)-AM | 724 | [3] |
| Igapó forest | Presidente Figueiredo-AM | 721 | [4] |
| Forested Campinarana | Presidente Figueiredo-AM | 616 | [4] |
| Terra Firme | São Sebastião do Uatumã-AM | 741 | [5] |
| Forested Campinarana | Manaus-AM | 470 | [6] |
| **Mean (trees.ha-1) ± SD** |  | **595 ± 95.3** |  |
| **Mean (10x25 plot) ± SD** |  | **14.9 ± 2.4** |  |

**Appendix B**

Table S2. Satellite image collection and specifications.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Specification /Satellite** | **Landsat 8** | | **Sentinel 2** | | **WorldView 2** | |
| Sensor | OLI | | MSI | | Pan-MS | |
| Scene | 231/062 | | T56MNN | | Order | |
| Level/Collection | 01 / C01 | | 01-C/-T-01 | | - | |
| Available Bands | 12 | | 16 | | 9 | |
| Used bands | 2-7 | | 2-8, 8A | | 2-8 | |
| Reflectance calibration | TOA | | TOA | | Radiance | |
| Provider | USGS | | ESA/Copernicus | | Digital Globe | |
| Pixel resolution (meters) | 30 | | 10 - 20 | | 2 | |
| Radiometric resolution (bits) | 16 | | 12 | | 11 | |
| Temporal resolution (days) | 16 | | ~5 | | 1,1 | |
| **Used scenes** | **Before** | **After** | **Before** | **After** | **Before** | **After** |
| Cloud Cover (%) | 0,1 | 1,2 | 3,11 | 0,02 | - | 0,002 |
| Scene date (year/month/day) | 11/09/2015 | 27/07/2016 | 25/08/2015 | 30/07/2016 | - | 27/07/2016 |
| Google Earth Engine ID | LANDSAT/LC08/C02/T1\_RT\_TOA/LC08\_231062\_20150911 | LANDSAT/LC08/C01/T1\_TOA/LC08\_231062\_20160727 | COPERNICUS/S2\_HARMONIZED/20150825T143316\_20150825T143317\_T20MQB | COPERNICUS/S2\_HARMONIZED/20160730T142756\_20160730T193520\_T20MRB | - | - |

Table S3. Forest inventory and satellite estimates for the filed subplots. AT = Number of Alive trees, DT = Field-based estimated tree-mortality, TT = number of total trees (AT + DT), NPV = values of non-photosynthetic vegetation recorded by satellites, PTM = percentage of tree mortality estimated by satellites in the subplots, L8 = Landsat 8, S2 = Sentinel 2, and W2 = WorldView 2.

| **Transect** | **Subplot** | **AT (Subplot)** | **AT (ha)** | **DT (Subplot)** | **DT (ha)** | **TT (Subplot)** | **TT (ha)** | **Field PTM** | **NPV** | | | **PTM** | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **L8** | **S2** | **W2** | **L8** | **S2** | **W2** |
| VQQ1 | VQQ11D | 8 | 320 | 7 | 280 | 15 | 600 | 46,7 | 0,172 | 0,076 | 0,070 | 16,8 | 14,2 | 15,4 |
|  | VQQ11E | 10 | 400 | 5 | 200 | 15 | 600 | 33,3 | 0,172 | 0,113 | 0,146 | 16,8 | 15,9 | 22,3 |
|  | VQQ12D | 16 | 640 | 0 | 0 | 16 | 640 | 0,0 | 0,095 | 0,013 | 0,070 | 12,8 | 11,7 | 15,3 |
|  | VQQ12E | 15 | 600 | 0 | 0 | 15 | 600 | 0,0 | 0,108 | 0,045 | 0,058 | 13,5 | 12,9 | 14,4 |
|  | VQQ13D | 9 | 360 | 6 | 240 | 15 | 600 | 40,0 | 0,082 | 0,102 | 0,065 | 12,3 | 15,3 | 15,0 |
|  | VQQ13E | 7 | 280 | 8 | 320 | 15 | 600 | 53,3 | 0,096 | 0,117 | 0,031 | 12,9 | 16,1 | 12,6 |
|  | VQQ14D | 8 | 320 | 7 | 280 | 15 | 600 | 46,7 | 0,164 | 0,159 | 0,071 | 16,3 | 18,1 | 15,5 |
|  | VQQ14E | 13 | 520 | 2 | 80 | 15 | 600 | 13,3 | 0,156 | 0,160 | 0,133 | 15,9 | 18,2 | 21,0 |
|  | VQQ15D | 13 | 520 | 2 | 80 | 15 | 600 | 13,3 | 0,335 | 0,178 | 0,119 | 28,2 | 19,2 | 19,7 |
|  | VQQ15E | 10 | 400 | 5 | 200 | 15 | 600 | 33,3 | 0,344 | 0,218 | 0,102 | 29,0 | 21,5 | 18,1 |
| VQQ2 | VQQ21D | 16 | 640 | 0 | 0 | 16 | 640 | 0,0 | 0,106 | 0,112 | 0,097 | 13,4 | 15,8 | 17,7 |
|  | VQQ21E | 11 | 440 | 4 | 160 | 15 | 600 | 26,7 | 0,093 | 0,015 | 0,106 | 12,7 | 11,7 | 18,4 |
|  | VQQ22D | 14 | 560 | 1 | 40 | 15 | 600 | 6,7 | 0,051 | 0,067 | 0,101 | 11,0 | 13,8 | 18,0 |
|  | VQQ22E | 14 | 560 | 1 | 40 | 15 | 600 | 6,7 | 0,035 | 0,035 | 0,085 | 10,3 | 12,5 | 16,6 |
|  | VQQ23D | 15 | 600 | 0 | 0 | 15 | 600 | 0,0 | 0,086 | 0,084 | 0,099 | 12,4 | 14,5 | 17,8 |
|  | VQQ23E | 15 | 600 | 0 | 0 | 15 | 600 | 0,0 | 0,089 | 0,128 | 0,090 | 12,6 | 16,6 | 17,0 |
|  | VQQ24D | 14 | 560 | 1 | 40 | 15 | 600 | 6,7 | 0,088 | 0,071 | 0,108 | 12,5 | 14,0 | 18,7 |
|  | VQQ24E | 18 | 720 | 0 | 0 | 18 | 720 | 0,0 | 0,136 | 0,099 | 0,049 | 14,8 | 15,2 | 13,7 |
|  | VQQ25D | 16 | 640 | 0 | 0 | 16 | 640 | 0,0 | 0,074 | 0,006 | 0,038 | 11,9 | 11,4 | 13,0 |
|  | VQQ25E | 18 | 720 | 0 | 0 | 18 | 720 | 0,0 | 0,102 | 0,056 | 0,054 | 13,2 | 13,3 | 14,2 |
| VQQ3 | VQQ31D | 3 | 120 | 12 | 480 | 15 | 600 | 80,0 | 0,902 | 0,895 | 0,551 | 80,1 | 75,0 | 77,2 |
|  | VQQ31E | 6 | 240 | 9 | 360 | 15 | 600 | 60,0 | 0,893 | 0,888 | 0,587 | 79,5 | 74,6 | 80,8 |
|  | VQQ32D | 1 | 40 | 14 | 560 | 15 | 600 | 93,3 | 0,897 | 0,789 | 0,346 | 79,8 | 67,4 | 49,3 |
|  | VQQ32E | 2 | 80 | 13 | 520 | 15 | 600 | 86,7 | 0,890 | 0,844 | 0,444 | 79,3 | 71,5 | 63,8 |
|  | VQQ33D | 15 | 600 | 0 | 0 | 15 | 600 | 0,0 | 0,424 | 0,659 | 0,318 | 36,2 | 56,6 | 45,1 |
|  | VQQ33E | 6 | 240 | 9 | 360 | 15 | 600 | 60,0 | 0,384 | 0,663 | 0,432 | 32,5 | 57,0 | 62,1 |
|  | VQQ34D | 11 | 440 | 4 | 160 | 15 | 600 | 26,7 | 0,356 | 0,347 | 0,152 | 30,1 | 30,1 | 23,0 |
|  | VQQ34E | 5 | 200 | 10 | 400 | 15 | 600 | 66,7 | 0,356 | 0,246 | 0,144 | 30,1 | 23,2 | 22,2 |
|  | VQQ35D | 14 | 560 | 1 | 40 | 15 | 600 | 6,7 | 0,260 | 0,148 | 0,124 | 22,5 | 17,6 | 20,1 |
|  | VQQ35E | 18 | 720 | 0 | 0 | 18 | 720 | 0,0 | 0,284 | 0,184 | 0,085 | 24,2 | 19,5 | 16,6 |
| **Total** |  | **341** | **-** | **121** | **-** | **462** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| **Mean** |  | **11,4** | **455** | **4,0** | **161** | **15,4** | **616,0** | **26,9** | **0,274** | **0,251** | **0,163** | **26,5** | **26,5** | **26,5** |
| IC (95%) |  | 1,8 | 70,2 | 1,6 | 63,7 | 0,3 | 13,3 | 11,1 | 0,101 | 0,107 | 0,058 | 8.4 | 7,9 | 7,4 |
| Median |  | 13,0 | 520,0 | 2,0 | 80,0 | 15,0 | 600,0 | 13,3 | 0,160 | 0,123 | 0,102 | 16,1 | 16,3 | 18,0 |

**Appendix C**

We use ∆NPV for the Landsat 8 and Sentinel 2 satellites to test the patterns of values obtained for the subplots. The results showed that GLM models using ∆NPV showed similar fit metrics between field and remote sensing data (Table S4; Figure S5; Figure S6). Similarly, variations and uncertainties associated with the mean percentage of tree mortality were similar to values using only post-disturbance NPV and tendency of estimation of tree mortality along the severity gradient (Table S5; Table S6; Figure S7). Thus, these results allowed us to use post-disturbance NPV for all satellites allowing comparisons between them.

Table S4. Fitting summary of GLM models used to relate field with remote sensing estimates using ∆NPV for Landsat 8 and Sentinel 2 of windthrow tree-mortality in a Central Amazon forest, Brazil. AIC = Akaike Information Criteria; Syx = standard error of the estimates; RMSE = root mean square error; Sigma = residual standard deviation; R²KL = Kullback-Leibler coefficient of determination.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **Residual Deviance** | **AIC** | **Syx** | **RMSE** | **Sigma** | **R²KL** | **Coefficients** | |
| a (intercept) | b (slope) |
| L8 | 136.95 | 194.99 | 0.2274 | 0.208 | 2,212 | 0.3817 | 0.1118 | 0.9860 |
| S2 | 139.61 | 197.65 | 0.2311 | 0.211 | 2,223 | 0.3697 | 0.1314 | 0.9756 |

Gráfico

Descrição gerada automaticamente

Figure S5. GLM models describing the relationship between windthrow tree-mortality measured in the field and estimated using remote sensing data. (a) Functions describing the relationship between ∆NPV and windthrow tree-mortality (%) measured in the field; (b) Trend curves for windthrow tree-mortality estimated from remote sensing and measured in the field. The black dotted and red lines are the 1:1 line (perfect linear relationship) and the actual relationship between observed and estimated values, respectively; (c) Residual distribution of fitted models.

Diagrama

Descrição gerada automaticamente

Figure S6. Distribution of windthrow tree-mortality (%) estimated from satellite data using ∆NPV for Landsat 8 and Sentinel 2 with varying spatial resolution (i.e., from 10 m to 30 m pixel). a) Windthrow tree-mortality in the field subplots. b) Windthrow tree-mortality in the virtual subplots. The hollow black circles show the outliers.

Table S5. Descriptive statistics for windthrow tree-mortality (%) measured from field and estimated by remote sensing data using ∆NPV for Landsat 8 and Sentinel 2 for a Central Amazon forest, Brazil. Min and Max- minimum and maximum values; Q1 and Q3- first and third median quartiles; Iqr- Interquartile range; SD- Standard Deviation; SE- Standard Error; CI- 95% Confidence Interval. \*The mean of windthrow tree mortality values in the field subplots was statiscally similar among satellites due the linear modeling properties. All windthrow tree-mortality were normalized to the area of the field subplots (10x25m) to allow for comparisons between satellites.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Plot type** | **Measure** | **Min** | **Max** | **Median** | **Q1** | **Q3** | **Iqr** | **Mean** | **SD** | **SE** | **CI** |
| Field | Field | 0.0 | 93.0 | 13.0 | 0.0 | 47.0 | 47.0 | 26.9 | 29.7 | 5.4 | 11.1 |
|  | L8 | 11.3 | 76.0 | 16.7 | 13.2 | 25.0 | 11.9 | 26.5 | 21.2 | 3.9 | 7.9 |
|  | S2 | 13.3 | 75.6 | 16.8 | 14.4 | 21.4 | 7.0 | 26.5 | 21.0 | 3.8 | 7.8 |
| Virtual | L8 | 11.2 | 79.0 | 13.6 | 11.9 | 45.1 | 33.1 | 27.3 | 21.7 | 2.2 | 4.3 |
|  | S2 | 13.1 | 82.5 | 18.9 | 15.3 | 43.9 | 28.6 | 30.9 | 20.6 | 2.1 | 4.1 |

Table S6. Forest inventory and satellite estimates using ∆NPV for Landsat 8 and Sentinel 2 for the filed subplots. AT = Number of Alive trees, DT = Field-based estimated tree-mortality, TT = number of total trees (AT + DT), NPV = values of non-photosynthetic vegetation recorded by satellites in the subplots, PTM = percentage of tree mortality estimated by satellites in the subplots, L8 = Landsat 8, S2 = Sentinel 2.

| **Plot** | **Subplot** | **AT** | **DT** | **TT (Subplot)** | **TT (ha)** | **Field PTM** | **∆NPV** | | **PTM Estimated by ∆NPV** | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **L8** | **S2** | **L8** | **S2** |
| VQQ1 | VQQ11D | 8 | 7 | 15 | 600 | 46.7 | 0.045 | 0.099 | 13.2 | 17.9 |
|  | VQQ11E | 10 | 5 | 15 | 600 | 33.3 | 0.044 | 0.133 | 13.2 | 19.8 |
|  | VQQ12D | 16 | 0 | 16 | 640 | 0.0 | 0.010 | 0.073 | 11.6 | 16.5 |
|  | VQQ12E | 15 | 0 | 15 | 600 | 0.0 | 0.021 | 0.086 | 12.1 | 17.2 |
|  | VQQ13D | 9 | 6 | 15 | 600 | 40.0 | 0.098 | 0.053 | 16.0 | 15.5 |
|  | VQQ13E | 7 | 8 | 15 | 600 | 53.3 | 0.110 | 0.039 | 16.7 | 14.9 |
|  | VQQ14D | 8 | 7 | 15 | 600 | 46.7 | 0.136 | 0.063 | 18.3 | 16.0 |
|  | VQQ14E | 13 | 2 | 15 | 600 | 13.3 | 0.166 | 0.030 | 20.3 | 14.5 |
|  | VQQ15D | 13 | 2 | 15 | 600 | 13.3 | 0.059 | 0.105 | 13.9 | 18.2 |
|  | VQQ15E | 10 | 5 | 15 | 600 | 33.3 | 0.062 | 0.084 | 14.1 | 17.1 |
| VQQ2 | VQQ21D | 16 | 0 | 16 | 640 | 0.0 | 0.040 | 0.035 | 13.0 | 14.7 |
|  | VQQ21E | 11 | 4 | 15 | 600 | 26.7 | 0.067 | 0.003 | 14.3 | 13.3 |
|  | VQQ22D | 14 | 1 | 15 | 600 | 6.7 | 0.162 | 0.007 | 20.0 | 13.4 |
|  | VQQ22E | 14 | 1 | 15 | 600 | 6.7 | 0.201 | 0.013 | 22.8 | 13.7 |
|  | VQQ23D | 15 | 0 | 15 | 600 | 0.0 | 0.021 | 0.007 | 12.1 | 13.4 |
|  | VQQ23E | 15 | 0 | 15 | 600 | 0.0 | 0.021 | 0.007 | 12.1 | 13.5 |
|  | VQQ24D | 14 | 1 | 15 | 600 | 6.7 | 0.003 | 0.003 | 11.3 | 13.3 |
|  | VQQ24E | 18 | 0 | 18 | 720 | 0.0 | 0.028 | 0.052 | 12.4 | 15.5 |
|  | VQQ25D | 16 | 0 | 16 | 640 | 0.0 | 0.168 | 0.027 | 20.5 | 14.3 |
|  | VQQ25E | 18 | 0 | 18 | 720 | 0.0 | 0.171 | 0.029 | 20.6 | 14.4 |
| VQQ3 | VQQ31D | 3 | 12 | 15 | 600 | 80.0 | 0.759 | 0.818 | 76.0 | 75.6 |
|  | VQQ31E | 6 | 9 | 15 | 600 | 60.0 | 0.755 | 0.799 | 75.7 | 74.2 |
|  | VQQ32D | 1 | 14 | 15 | 600 | 93.3 | 0.730 | 0.682 | 73.7 | 65.2 |
|  | VQQ32E | 2 | 13 | 15 | 600 | 86.7 | 0.641 | 0.747 | 65.7 | 70.5 |
|  | VQQ33D | 15 | 0 | 15 | 600 | 0.0 | 0.532 | 0.576 | 54.7 | 55.9 |
|  | VQQ33E | 6 | 9 | 15 | 600 | 60.0 | 0.501 | 0.611 | 51.4 | 59.1 |
|  | VQQ34D | 11 | 4 | 15 | 600 | 26.7 | 0.239 | 0.236 | 25.8 | 26.6 |
|  | VQQ34E | 5 | 10 | 15 | 600 | 66.7 | 0.281 | 0.168 | 29.4 | 21.9 |
|  | VQQ35D | 14 | 1 | 15 | 600 | 6.7 | 0.098 | 0.112 | 16.0 | 18.6 |
|  | VQQ35E | 18 | 0 | 18 | 720 | 0.0 | 0.110 | 0.121 | 16.7 | 19.1 |
| **Total** |  | **341** | **121** | **462** | **-** | **-** | **-** | **-** | **-** | **-** |
| **Mean** |  | **11.4** | **4.0** | **15.4** | **616.0** | **26.9** | **0.209** | **0.194** | **26.5** | **26.5** |
| IC (95%) |  | 1.8 | 1.6 | 0.3 | 13.3 | 11.1 | 0.086 | 0.096 | 7.9 | 7.8 |
| Median |  | 13.0 | 2.0 | 15.0 | 600.0 | 13.3 | 0.110 | 0.079 | 16.7 | 16.8 |

Gráfico, Diagrama

Descrição gerada automaticamente com confiança média

Figure S7. Percentual windthrow tree-mortality measured in the field and estimated by remote sensing data using ∆NPV for Landsat 8 and Sentinel 2 for a Central Amazon forest, Brazil. (a) Windthrow tree-mortality in Field subplots; (b) Windthrow tree-mortality in Virtual Subplots. In (a) and (b), we modeled windthrow tree-mortality estimates tendency using GLMs. The grey polygons in (a) and (b) indicate the 95% confidence interval. In the (a) plot legend, Field = Windthrow tree-mortality measured by Forest Inventory; PTM = Percentage of windthrow tree-mortality.

**Appendix D**

We used the ENVI 5.3 software toolkit to analytically extract the endmembers for each satellite. Five main steps were performed (Figure S8). First, we downloaded Landsat 8 and Sentinel 2 images at top-of-atmosphere reflectance (TOA) values directly from the Google Earth Engine platform. The WorldView 2 image was acquired in radiance values, and we used the parameters defined by [7] to correct the radiance values for TOA. This allowed us direct comparisons of the reflectance curves of each endmember, evaluating whether the selected endmembers had similar reflectance curves.

Second, we applied an endmember acquisition routine that consisted of three processes: (a) Minimum Noise Fraction Rotation (MNF) which uses principal component analysis to determine the dimensionality of the image data and segregate noise in the data [8]; (b) Purity Pixel Index which searches for the spectrally pure pixels within the images from the lowest noise bands selected by MNF [9]; (c) n-D Visualizer which displays the pixels within an n-dimensional space (i.e., made up from n-bands of the images) by means of a scatter plot that allows us to recognize clusters of pure pixels at the extremes of the distribution [9,10]. Each cluster provided a mean reflectance value of the selected group of pixels, forming the spectral signature of the endmember. We assembled a library of several candidate endmembers for GV, NPV, and Shade.

Third, with Spectral Mixture Analysis (SMA) we generated multiple GV, NPV, and Shade fraction images for each satellite from combinations of the various candidate endmembers. The NPV fractions were normalized without Shade to obtain values expressing proportions of dead vegetation between 0-1.

Fourth, we analyzed each NPV-fraction image from a rigorous quality process that considered the percentage of pixels with NPV values residing between 0-1 across the pixel total. Only fraction-images with at least 98% of their pixels within this range were selected. After that we analyzed the Residual Error (RMS) of each fraction image obtained with the SMA-process. The NPV fraction-images with the smallest RMS were selected. After that, each candidate fraction image was analyzed against an RGB composition of the same image to evaluate the field context and the correspondence between the damage patterns seen in the RGB image and those recorded in the NPV fraction image (Figure S9).

Fifth, in the QGIS environment [11], on the selected fraction images we selected a region of interest encompassing the area where the forest inventory was performed (Forest Inventory Region). We selected a region where the relief conditions were flatter to reduce the effect of shading from valley bottoms and slopes [12] and clipped the fraction images. After this, the clipped images were converted to vector shapefile format to allow geometric calculations. We calculated the area (m²) of each pixel (or segment) contained within the subplots by means of the Zonal Statistics tool.

Finally, we calculated the weighted mean of the NPV values by the area of each pixel (or segment) within each subplot. The weighted NPV values within each subplot were related to the percentage of tree mortality measured in the field using GLM.



Figure S8. Analysis routine for selecting endmembers used in Spectral Mixture Analysis and modeling.

Gráfico, Gráfico de linhas

Descrição gerada automaticamente

Figure S9. Spectral signature for the selected endmembers for (a) Landsat 8, (b) Sentinel 2, and (c) WorldView 2. GV = Green Vegetation; NPV = Non-photosynthetic vegetation.

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