

## Article

# Intra-annual variabilities of *Rubus caesius* L. discrimination on hyperspectral and LiDAR data

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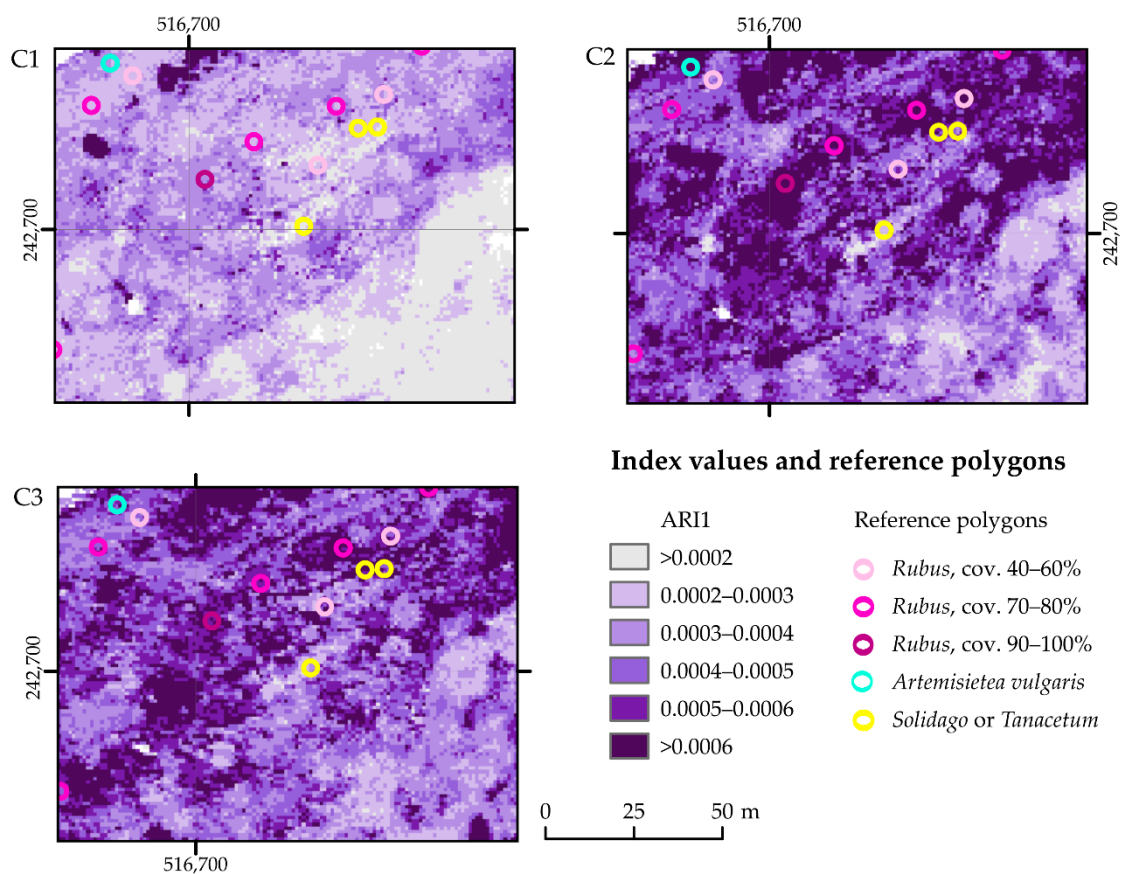
## Supplementary materials:

**Table S1. Remote sensing vegetation indices used in the study. R – reflectance value.**

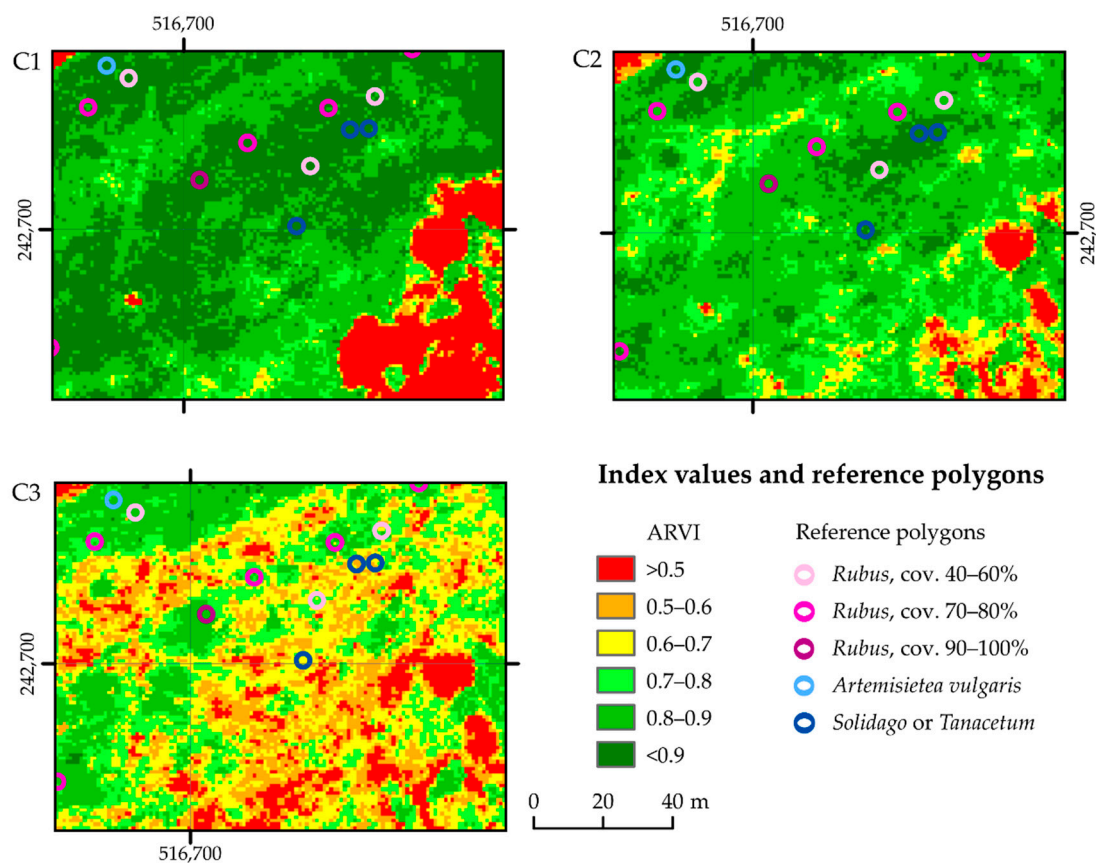
No.	Index	Equation	Source
Broadband Greenness			
1	Atmospherically Resistant Vegetation Index	$ARVI = (R_{NIR} - (2R_{RED} - R_{BLUE})) / (R_{NIR} + (2R_{RED} - R_{BLUE}))$	[1]
2	Difference Vegetation Index	$DVI = R_{NIR} - R_{RED}$	[2]
3	Enhanced Vegetation Index	$EVI = 2.5 \cdot ((R_{NIR} - R_{RED}) / (R_{NIR} + 6R_{RED} - 7.5R_{BLUE} + 1))$	[3]
4	Global Environmental Monitoring Index	$GEMI = \frac{eta(1 - 0.25 \cdot eta) - (R_{RED} - 0.125)}{(1 - R_{RED})}$ $eta = \frac{(2(R_{NIR}^2 - R_{RED}^2) + 1.5 \cdot R_{NIR} + 0.5 \cdot R_{RED})}{(R_{NIR} + R_{RED} + 0.5)}$	[4]
5	Green Atmospherically Resistant Index	$GARI = \frac{(R_{NIR} - (R_{GREEN} - 1.7 \cdot (R_{BLUE} - R_{RED})))}{(R_{NIR} + (R_{GREEN} - 1.7 \cdot (R_{BLUE} - R_{RED})))}$	[5]
6	Green Difference Vegetation Index	$GDVI = R_{NIR} - R_{GREEN}$	[6]
7	Green Normalized Difference Vegetation Index	$GNDVI = (R_{NIR} - R_{GREEN}) / (R_{NIR} + R_{GREEN})$	[7]
8	Green Ratio Vegetation Index	$GRVI = R_{NIR} / R_{GREEN}$	[8]
9	Green Vegetation Index	$GVI = -0.2848 \cdot R_{BLUE} - 0.2345 \cdot R_{GREEN} - 0.5436 \cdot R_{RED} + 0.7243 \cdot R_{NIR} + 0.084 \cdot R_{MIR1} - 0.18 \cdot R_{MIR2}$	[9]
10	Infrared Percentage Vegetation Index	$IPVI = R_{NIR} / (R_{NIR} + R_{RED})$	[10]
11	Leaf Area Index	$LAI = 3.618 \cdot EVI + 0.118$	[11]

No.	Index	Equation	Source
12	Modified Non-Linear Index	$MNLI = (1.5 \times (R_{NIR}^2 - R_{RED})) / (R_{NIR}^2 + R_{RED} + 0.5)$	[12]
13	Modified Simple Ratio	$MSR = (R_{NIR}/R_{RED} - 1) / (\sqrt{(R_{NIR}/R_{RED}) + 1})$	[13]
14	Non-Linear Index	$NLI = (R_{NIR}^2 - R_{RED}) / (R_{NIR}^2 + R_{RED})$	[14]
15	Normalized Difference Vegetation Index	$NDVI = (R_{NIR} - R_{RED}) / (R_{NIR} + R_{RED})$	[15]
16	Optimized Soil Adjusted Vegetation Index	$OSAVI = (R_{NIR} - R_{RED}) / (R_{NIR} + R_{RED} + 0.16)$	[16]
17	Renormalized Difference Vegetation Index	$RDVI = (R_{NIR} - R_{RED}) / \sqrt{(R_{NIR} + R_{RED})}$	[17]
18	Simple Ratio Index	$SR = R_{NIR}/R_{RED}$	[18]
19	Soil Adjusted Vegetation Index	$SAVI = 1.5 \times (R_{NIR} - R_{RED}) / (R_{NIR} + R_{RED} + 0.5)$	[19]
20	Sum Green Index	SGI is the average of the reflectance coefficient within the range from 500 nm to 600 nm	[20]
21	Transformed Difference Vegetation Index	$TDVI = 1.5 \times ((R_{NIR} - R_{RED}) / \sqrt{(R_{NIR}^2 + R_{RED} + 0.5)})$	[21]
22	Triangular Vegetation Index	TGI is an area of a triangle, where vertices are in RED, GREEN and BLUE bands	[22]
23	Visible Atmospherically Resistant Index	$VARI = (R_{GREEN} - R_{RED}) / (R_{GREEN} + R_{RED} + R_{BLUE})$	[23]
Narrowband Greenness			
24	Modified Chlorophyll Absorption Ratio Index	$MCARI = ((R_{700} - R_{670}) - 0.2(R_{700} - R_{550})) \times (R_{700}/R_{670})$	[24]
25	Modified Chlorophyll Absorption Ratio Index - Improved	$MCARII = (1.5 \times (2.5 \times (R_{800} - R_{670}) - 1.3 \times (R_{800} - R_{550}))) / \sqrt{((2 \times P_{800} + 1)^2 - (6 \times R_{800} - 5 \times \sqrt{(R_{670}))}) - 0.5}$	[25]
26	Modified Red Edge Normalized Difference Vegetation Index	$MRENDVI = (R_{750} - R_{705}) / (R_{750} + R_{705} - 2R_{445})$	[26,27]
27	Modified Red Edge Simple Ratio Index	$MRESRI = (R_{750} - R_{445}) / (R_{705} + R_{445})$	[26,27]
28	Modified Triangular Vegetation Index	$MTVI = 1.2 \times (1.2 \times (R_{800} - R_{550}) - 2.5 \times (R_{670} - R_{550}))$	[25]
29	Modified Triangular Vegetation Index - Improved	$MTVII = 1.5 \times (1.2 \times (R_{800} - R_{550}) - 2.5 \times (R_{670} - R_{550})) / \sqrt{((2 \times P_{800} + 1)^2 - (6 \times R_{800} - 5 \times \sqrt{(R_{670}))}) - 0.5}$	[25]
30	Red Edge Normalized Difference Vegetation Index	$RENDVI = (R_{750} - R_{705}) / (R_{750} + R_{705})$	[28]
31	Transformed Chlorophyll Absorption Reflectance Index	$TCARI = 3((R_{700} - R_{670}) - 0.2(R_{700} - R_{550}))(R_{700}/R_{670})$	[25]
32	Vogelmann Red Edge Index 1	$VREI1 = R_{740}/R_{720}$	[29]

No.	Index	Equation	Source
33	Vogelmann Red Edge Index 2	$VREI2 = (R_{734} - R_{747}) / (R_{715} + R_{726})$	[29]
Light Use Efficiency			
34	Photochemical Reflectance Index	$PRI = (R_{531} - R_{570}) / (R_{531} + R_{570})$	[30]
35	Structural Independent Pigment Index	$SIPI = (R_{800} - R_{445}) / (R_{800} - R_{680})$	[31]
36	Red Green Ratio Index	$RGRI = (\sum_{i=600}^{699} R_i) / (\sum_{j=500}^{599} R_j)$	[20]
Canopy Nitrogen			
37	Normalized Difference Nitrogen Index	$NDNI = (\log(1/R_{1510}) - \log(1/R_{1680})) / (\log(1/R_{1510}) + \log(1/R_{1680}))$	[32]
Dry or Senescent Carbon			
38	Cellulose Absorption Index	$CAI = 0.5(R_{2000} + R_{2200}) - R_{2100}$	[33]
39	Normalized Difference Lignin Index	$NDLI = (\log(1/R_{1754}) - \log(1/R_{1680})) / (\log(1/R_{1754}) + \log(1/R_{1680}))$	[32]
40	Plant Senescence Reflectance Index	$PSRI = (R_{680} - R_{500}) / R_{750}$	[34]
Leaf Pigments			
41	Anthocyanin Reflectance Index 1	$ARI1 = 1/R_{550} - 1/R_{700}$	[35]
42	Anthocyanin Reflectance Index 2	$ARI1 = R_{800}(1/R_{550} - 1/R_{700})$	[35]
43	Carotenoid Reflectance Index 1	$CRI1 = 1/R_{510} - 1/R_{550}$	[36]
44	Carotenoid Reflectance Index 2	$CRI2 = 1/R_{510} - 1/R_{700}$	[36]
Canopy Water Content			
45	Modified Normalized Difference Water Index	$NNDWI = (R_{GREEN} - R_{MIR}) / (R_{GREEN} + R_{MIR})$	[37]
46	Moisture Stress Index	$MSI = R_{1599} / R_{819}$	[38,39]
47	Normalized Difference Infrared Index	$NDII = (R_{819} - R_{1649}) / (R_{819} + R_{1649})$	[40]
48	Normalized Difference Water Index	$NDWI = (R_{857} - R_{1241}) / (R_{857} + R_{1241})$	[41]
49	Water Band Index	$WBI = R_{970} / R_{900}$	[42]



**Figure S1.** The spatial distribution of ARI1 classes for three campaigns on selected area.



**Figure S2.** The spatial distribution of ARVI classes for three campaigns on selected area.

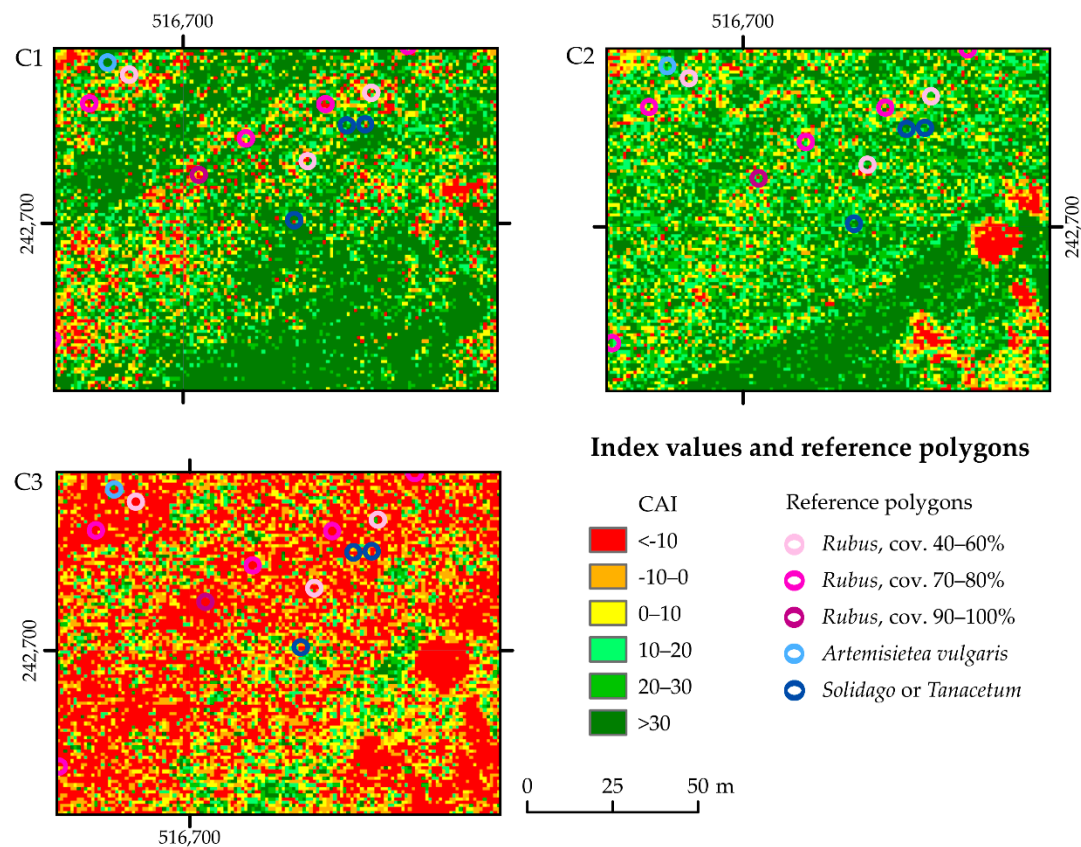


Figure S3. The spatial distribution of CAI classes for three campaigns on selected area.

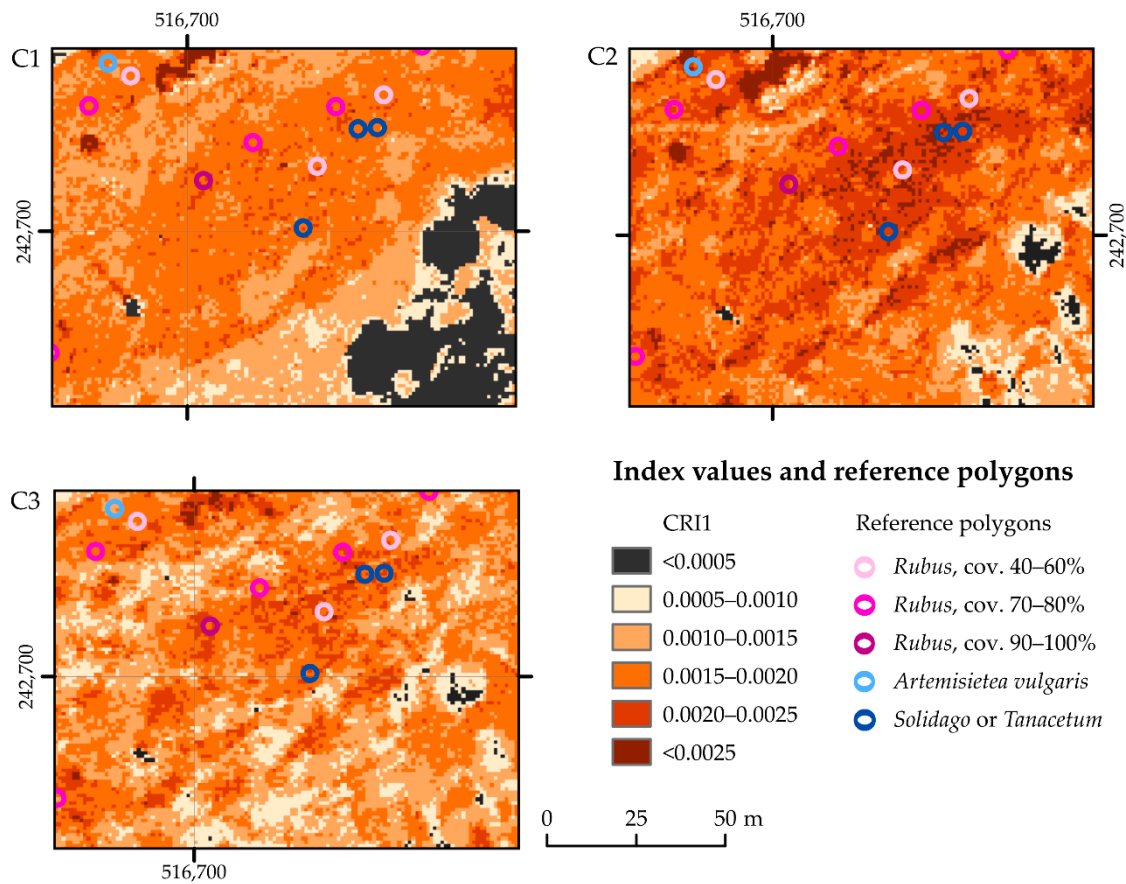
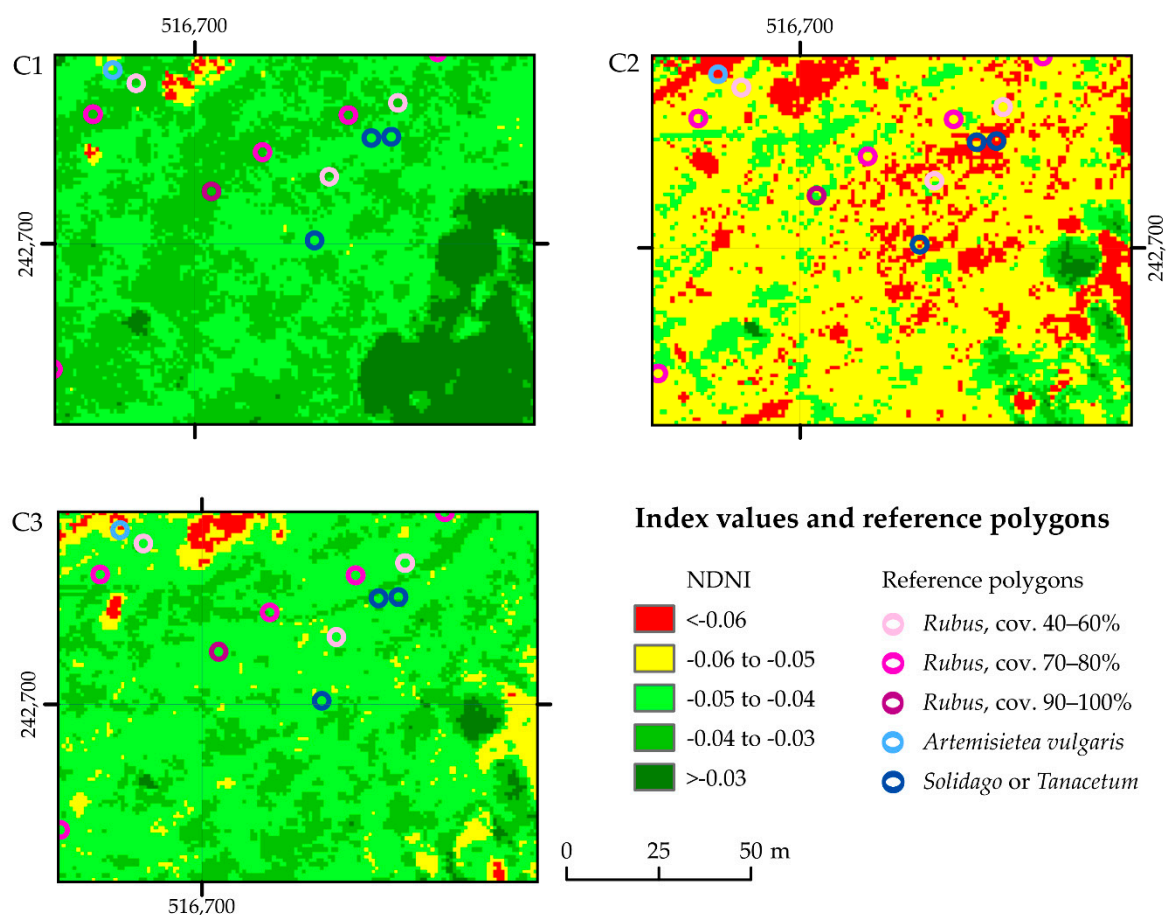


Figure S4. The spatial distribution of CRI1 classes for three campaigns on selected area.



**Figure S5.** The spatial distribution of NDNI classes for three campaigns on selected area.

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