Scientific background material for the “vegspec” package in Python

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The goal of the “vegspec” package in Python is to encapsulate the computations of 1) more than 145 published spectral vegetation indices and 2) several published pretreatment transformations for vegetative spectral reflectance data (ρ). An exhaustive literature search identified more than 145 spectral vegetation indices developed in remote sensing science from 1968 to the present time (Table 1). Additionally, the evaluated plant species, scale of remote sensing data, and the evaluated dependent variables were collected from the the original publications for each index (Table 2).

Given input of a single vegetative reflectance spectrum, the “vegspec” package computes each spectral vegetation index and encapsulates the results for use in further data analysis. A main advancement of the package is its representation of the spectral vegetation indices using the syntax of both the Python programming language and the LaTeX typesetting system, the latter of which rendered each index in mathematical notation as presented in Table 1. For indices that required “soil line” parameters, the slope (a) was specified as 1.166 and the intercept (b) was specified as 0.042, based on Huete et al. (1984) who reported mean soil line parameters for 20 soils with varying spectral properties. However, users can also specify their own soil line parameters, if desired.

Remote sensing literature over the past decades has also documented several preprocessing treatments to condition spectral reflectance data prior to analysis. Examples include 1) the first and second derivatives of spectral reflectance (ρ' and ρ'', respectively) (Horler et al., 1983), 2) the base-10 logarithm ($\log_{10}$) of the inverse of spectral reflectance and its first and second derivatives ($\log_{10}\rho^{-1}$, $(\log_{10}\rho^{-1})'$, and $(\log_{10}\rho^{-1})''$, respectively) (Blackburn, 1998a; Yoder and Pettigrew-Crosby, 1995), and 3) band depth or continuum removal analysis of reflectance spectra (ρ_{CR}) (Curran et al., 2001; Huang et al., 2004; Kokaly and Clark, 1999). Given input of a single vegetative reflectance spectrum, the “vegspec” package computes these six pretreatments and encapsulates the results for use in further data analysis. Spectral derivatives are computed using a Savitsky-Golay filter in Python’s “scipy” package (Virtanen et al., 2020), and continuum removal analysis requires use of a convex hull algorithm also in scipy. Computations of spectral derivatives were required for computation of several spectral vegetation indices.

Table 1: Chronological summary of 148 spectral vegetation indices developed from 1968 to the present time. Indices are defined using formulas based on reflectance (ρ), the first derivative of reflectance (ρ'), and the second derivative of reflectance (ρ'') with wavelengths (λ) identified either specifically in nanometers (i.e., λ_{675}) or generally as blue (λ_{BLU}), green (λ_{GRN}), red (λ_{RED}), red edge (λ_{RDE}), or near-infrared (λ_{NIR}) wavebands.

Year	Code	Description	Type[1]	Formula	Citation
1968	BRSR	Birth simple ratio	SR	$\frac{\rho_{745}}{\rho_{675}}$	Birth and McVey (1968)
1969	JSR	Jordan simple ratio	SR	$\frac{\rho_{800}}{\rho_{675}}$	Jordan (1969)
1973	NDVI	Normalized Difference Vegetation Index (NDVI)	ND	$\frac{\rho_{\mathrm{NIR}}-\rho_{\mathrm{RED}}}{\rho_{\mathrm{NIR}}+\rho_{\mathrm{RED}}}$	Rouse et al. (1973)
1977	PVI	Perpendicular Vegetation Index (PVI)	SA	$\frac{\rho_{\mathrm{NIR}}-a\rho_{\mathrm{RED}}-b}{\sqrt{1+a^2}}:(a=1.166,b=0.024)$	Richardson and Wiegand (1977); Jackson et al. (1980); Huete et al. (1984)
1978	WLREIP	Wavelength of red edge inflection point	SF	$\lambda_{\mathrm{RDE}}=\arg\max_{\lambda}(\rho'(\lambda):680\leq\lambda\leq750)$	Collins (1978); Horler et al. (1983)
1979	DVI	Difference Vegetation Index (DVI)	DF	$\rho_{\mathrm{NIR}}-\rho_{\mathrm{RED}}$	Tucker (1979)
1979	NDVI2	Normalized Difference Vegetation Index 2 (NDVI2)	ND	$\frac{\rho_{\mathrm{GRN}}-\rho_{\mathrm{RED}}}{\rho_{\mathrm{GRN}}+\rho_{\mathrm{RED}}}$	Tucker (1979)

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Year	Code	Description	Type[1]	Formula	Citation
1988	WLREIP2	Wavelength of red edge inflection point 2	SF	$700+40\left(\frac{(\rho_{670}+\rho_{780})/2-\rho_{700}}{\rho_{740}-\rho_{700}}\right)$	Guyot and Baret (1988); Cho and Skidmore (2006)
1988	SAVI	Soil-Adjusted Vegetation Index (SAVI)	SA	$(1+L)\left(\frac{\rho_{\mathrm{NIR}}-\rho_{\mathrm{RED}}}{\rho_{\mathrm{NIR}}+\rho_{\mathrm{RED}}+L}\right):(L=0.5)$	Huete (1988)
1989	TSAVI	Transformed Soil-Adjusted Vegetation Index (TSAVI)	SA	$\frac{a(\rho_{\mathrm{NIR}}-a\rho_{\mathrm{RED}}-b)}{\rho_{\mathrm{RED}}+a\rho_{\mathrm{NIR}}-ab}:(a=1.166,b=0.024)$	Baret et al. (1989); Huete et al. (1984)
1989	WDVI	Weighted Difference Vegetation Index (WDVI)	SA	$\rho_{\mathrm{NIR}}-C\rho_{\mathrm{RED}}:(C=1.166)$	Clevers (1989); Huete et al. (1984)
1989	MSI	Moisture Stress Index	SR	$\frac{\rho_{1600}}{\rho_{820}}$	Hunt and Rock (1989)
1990	BD	Boochs derivative	SF	ρ'_{703}	Boochs et al. (1990)
1990	BDR	Boochs derivative ratio	SF	$\frac{\rho'_{703}}{\max(\rho'(\lambda):680\leq\lambda\leq 750)}$	Boochs et al. (1990)
1990	SAVI2	Soil-Adjusted Vegetation Index 2 (SAVI2)	SA	$\frac{\rho_{\mathrm{NIR}}}{\rho_{\mathrm{RED}}+b/a}:(a=1.166,b=0.024)$	Major et al. (1990); Huete et al. (1984)

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Year	Code	Description	Type[1]	Formula	Citation
1990	WLREIPG	Wavelength of red edge inflection point, Gaussian fit	SF	$\lambda_{\mathrm{RDE}} = \lambda_0 + \sigma : \rho(\lambda) = \rho_{\mathrm{s}} - (\rho_{\mathrm{s}} - \rho_0)\exp\left(\frac{-(\lambda_0 - \lambda)^2}{2\sigma^2}\right)$	Miller et al. (1990)
1990	WLCWMRG	Wavelength of chlorophyll-well minimum reflectance, Gaussian fit	SF	$\lambda_0 : \rho(\lambda) = \rho_{\mathrm{s}} - (\rho_{\mathrm{s}} - \rho_0)\exp\left(\frac{-(\lambda_0 - \lambda)^2}{2\sigma^2}\right)$	Miller et al. (1990)
1991	TSAVI2	Transformed Soil-Adjusted Vegetation Index 2 (TSAVI2)	SA	$\frac{a(\rho_{\mathrm{NIR}} - a\rho_{\mathrm{RED}} - b)}{a\rho_{\mathrm{NIR}} + \rho_{\mathrm{RED}} - ab + X(1+a^2)} : (X = 0.08, a = 1.166, b = 0.024)$	Baret and Guyot (1991); Huete et al. (1984)
1992	CPSR1	Chappelle simple ratio 1	SR	$\frac{\rho_{675}}{\rho_{700}}$	Chappelle et al. (1992)
1992	CPSR2	Chappelle simple ratio 2	SR	$\frac{\rho_{675}}{\rho_{650}\rho_{700}}$	Chappelle et al. (1992)
1992	CPSR3	Chappelle simple ratio 3	SR	$\frac{\rho_{760}}{\rho_{500}}$	Chappelle et al. (1992)
1992	PRI	Photochemical Reflectance Index (PRI)	ND	$\frac{\rho_{550} - \rho_{531}}{\rho_{550} + \rho_{531}}$	Gamon et al. (1992)
1992	GEMI	Global Environment Monitoring Index (GEMI)	EN	$\eta(1 - 0.25\eta) - \frac{\rho_{\mathrm{RED}} - 0.125}{1 - \rho_{\mathrm{RED}}} : (\eta = \frac{2(\rho_{\mathrm{NIR}}^2 - \rho_{\mathrm{RED}}^2) + 1.5\rho_{\mathrm{NIR}} + 0.5\rho_{\mathrm{RED}}}{\rho_{\mathrm{NIR}} + \rho_{\mathrm{RED}} + 0.5}$	Pinty and Verstraete (1992)

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Year	Code	Description	Type[1]	Formula	Citation
1993	BMSR	Buschmann simple ratio	SR	$\frac{\rho_{550}}{\rho_{800}}$	Buschmann and Nagel (1993)
1993	BMLSR	Buschmann log simple ratio	SR	$\log_{10}\left(\frac{\rho_{800}}{\rho_{550}}\right)$	Buschmann and Nagel (1993)
1993	BMDVI	Bushmann difference vegetation index	DF	$\rho_{800} - \rho_{550}$	Buschmann and Nagel (1993)
1993	PSR	Peñuelas simple ratio	SR	$\frac{\rho_{970}}{\rho_{900}}$	Peñuelas et al. (1993)
1993	PD	Peñuelas derivative	SF	$\min(\rho'(\lambda) : 900 \leq \lambda \leq 970)$	Peñuelas et al. (1993)
1993	WLPD	Wavelength of PD	SF	$\arg\min_{\lambda}(\rho'(\lambda) : 900 \leq \lambda \leq 970)$	Peñuelas et al. (1993)
1993	VSR	Vogelmann simple ratio	SR	$\frac{\rho_{740}}{\rho_{720}}$	Vogelmann et al. (1993)
1993	VDR	Vogelmann derivative ratio	SF	$\frac{\rho'_{715}}{\rho'_{705}}$	Vogelmann et al. (1993)
1994	CRSR1	Carter simple ratio 1	SR	$\frac{\rho_{695}}{\rho_{420}}$	Carter (1994)

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Year	Code	Description	Type[1]	Formula	Citation
1994	CRSR2	Carter simple ratio 2	SR	$\frac{\rho_{605}}{\rho_{760}}$	Carter (1994)
1994	CRSR3	Carter simple ratio 3	SR	$\frac{\rho_{695}}{\rho_{760}}$	Carter (1994)
1994	CRSR4	Carter simple ratio 4	SR	$\frac{\rho_{710}}{\rho_{760}}$	Carter (1994)
1994	CRSR5	Carter simple ratio 5	SR	$\frac{\rho_{695}}{\rho_{670}}$	Carter (1994)
1994	FSUM	Area of the first derivative red edge peak from 680 nm to 780 nm	SF	$\sum_{\lambda=680}^{780} \rho'(\lambda) d\lambda$	Filella and Peñuelas (1994); Filella et al. (1995)
1994	DREIP	Amplitude of the first derivative at red edge inflection point	SF	$\max(\rho'(\lambda) : 680 \leq \lambda \leq 780)$	Filella and Peñuelas (1994); Filella et al. (1995)
1994	NDVI3	Normalized Difference Vegetation Index 3 (NDVI3)	ND	$\frac{\rho_{750} - \rho_{705}}{\rho_{750} + \rho_{705}}$	Gitelson and Merzlyak (1994)
1994	GSUM1	Sum of reflectance from 705 nm to 750 nm, normalized by reflectance at 705 nm	SF	$\sum_{\lambda=705}^{750} \left(\frac{\rho(\lambda)}{\rho_{705}} - 1 \right) d\lambda$	Gitelson and Merzlyak (1994)

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Year	Code	Description	Type[1]	Formula	Citation
1994	GSUM2	Sum of reflectance from 705 nm to 750 nm, normalized by reflectance at 555 nm	SF	$\sum_{\lambda=705}^{750} \left(\frac{\rho(\lambda)}{\rho_{555}} - 1 \right) d\lambda$	Gitelson and Merzlyak (1994)
1994	NLI	Nonlinear Index (NLI)	ND	$\frac{\rho_{\mathrm{NIR}}^2 - \rho_{\mathrm{RED}}}{\rho_{\mathrm{NIR}}^2 + \rho_{\mathrm{RED}}}$	Goel and Qin (1994)
1994	CAR	Chlorophyll Absorption in Reflectance (CAR)	SF	$\sqrt{\frac{(b^T b)(a^T a) - (a^T b)^2}{(a^T a)}} : \left(a = \begin{bmatrix} \lambda_{700} - \lambda_{550} \\ \rho_{700} - \rho_{550} \end{bmatrix}, b = \begin{bmatrix} \lambda_{670} - \lambda_{550} \\ \rho_{670} - \rho_{550} \end{bmatrix} \right)$	Kim et al. (1994)
1994	CARI	Chlorophyll Absorption Ratio Index (CARI)	SF	$\mathrm{CAR} \times \left(\frac{\rho_{700}}{\rho_{670}} \right)$	Kim et al. (1994)
1994	NPCI	Normalized Pigments Chlorophyll ratio Index (NPCI)	ND	$\frac{\rho_{680} - \rho_{430}}{\rho_{680} + \rho_{430}}$	Peñuelas et al. (1994)
1994	EGFN	Edge-Green First-derivative Normalised difference index (EGFN)	SF	$\frac{\max(\rho'(\lambda_{\mathrm{RDE}})) - \max(\rho'(\lambda_{\mathrm{GRN}}))}{\max(\rho'(\lambda_{\mathrm{RDE}})) + \max(\rho'(\lambda_{\mathrm{GRN}}))} : (500 \leq \lambda_{\mathrm{GRN}} \leq 600, 680 \leq \lambda_{\mathrm{RDE}} \leq 750)$	Peñuelas et al. (1994)

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Year	Code	Description	Type[1]	Formula	Citation
1994	MSAVI1	Modified Soil-Adjusted Vegetation Index 1 (MSAVI1)	SA	$(1+L)\left(\frac{\rho_{\text{NIR}}-\rho_{\text{RED}}}{\rho_{\text{NIR}}+\rho_{\text{RED}}+L}\right):(L=1-2a\times\text{NDVI}\times\text{WDVI}, a=1.166)$	Qi et al. (1994); Huete et al. (1984)
1994	MSAVI2	Modified Soil-Adjusted Vegetation Index 2 (MSAVI2)	SA	$\frac{2\rho_{\text{NIR}}+1-\sqrt{(2\rho_{\text{NIR}}+1)^2-8(\rho_{\text{NIR}}-\rho_{\text{RED}})}}{2}$	Qi et al. (1994)
1995	ESUM1	Area of the first derivative red edge peak from 626 nm to 795 nm	SF	$\sum_{\lambda=626}^{795}\lvert\rho'(\lambda)\rvert d\lambda$	Elvidge and Chen (1995)
1995	ESUM2	Area of the second derivative red edge peaks from 626 nm to 795 nm	SF	$\sum_{\lambda=626}^{795}\lvert\rho''(\lambda)\rvert d\lambda$	Elvidge and Chen (1995)
1995	NDPI	Normalized Difference Pigment Index (NDPI)	ND	$\frac{\rho_{670}-\rho_{420}}{\rho_{670}+\rho_{420}}$	Peñuelas et al. (1995a)
1995	SIPI	Structure Independent Pigment Index (SIPI)	ND	$\frac{\rho_{800}-\rho_{445}}{\rho_{800}-\rho_{680}}$	Peñuelas et al. (1995a)
1995	SRPI	Simple Ratio Pigment Index (SRPI)	SR	$\frac{\rho_{430}}{\rho_{680}}$	Peñuelas et al. (1995b)

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Year	Code	Description	Type[1]	Formula	Citation
1995	NPQI	Normalized Phaeophytinization Index (NPQI)	ND	$\frac{\rho_{415}-\rho_{435}}{\rho_{415}+\rho_{435}}$	Peñuelas et al. (1995b)
1995	RDVI	Renormalized Difference Vegetation Index (RDVI)	ND	$\frac{\rho_{\text{NIR}}-\rho_{\text{RED}}}{\sqrt{\rho_{\text{NIR}}+\rho_{\text{RED}}}}$	Roujean and Breon (1995)
1996	MSR	Modified Simple Ratio (MSR)	EN	$\frac{\rho_{\text{NIR}}/\rho_{\text{RED}}-1}{\sqrt{\rho_{\text{NIR}}/\rho_{\text{RED}}+1}}$	Chen (1996); Roujean and Breon (1995)
1996	PRI2	Photochemical Reflectance Index 2 (PRI2)	ND	$\frac{\rho_{539}-\rho_{570}}{\rho_{539}+\rho_{570}}$	Filella et al. (1996)
1996	NDWI	Normalized Difference Water Index (NDWI)	ND	$\frac{\rho_{860}-\rho_{1240}}{\rho_{860}+\rho_{1240}}$	Gao (1996)
1996	GTSR1	Gitelson simple ratio 1	SR	$\frac{\rho_{750}}{\rho_{550}}$	Gitelson and Merzlyak (1996, 1997); Lichtenthaler et al. (1996)

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Year	Code	Description	Type[1]	Formula	Citation
1996	GTSR2	Gitelson simple ratio 2	SR	$\frac{\rho_{750}}{\rho_{700}}$	Gitelson and Merzlyak (1996, 1997); Lichtenthaler et al. (1996)
1996	GNDVI	Green Normalized Difference Vegetation Index (GNDVI)	ND	$\frac{\rho_{\mathrm{NIR}} - \rho_{\mathrm{GRN}}}{\rho_{\mathrm{NIR}} + \rho_{\mathrm{GRN}}}$	Gitelson et al. (1996)
1996	OSAVI	Optimized Soil-Adjusted Vegetation Index (OSAVI)	SA	$(1 + L)\left(\frac{\rho_{\mathrm{NIR}} - \rho_{\mathrm{RED}}}{\rho_{\mathrm{NIR}} + \rho_{\mathrm{RED}} + L}\right) : (L = 0.16)$	Rondeaux et al. (1996)
1997	WI	Water Index (WI)	SR	$\frac{\rho_{900}}{\rho_{970}}$	Peñuelas et al. (1997)
1997	WNR	WI NDVI ratio	EN	$\frac{\mathrm{WI}}{\mathrm{NDVI}}$	Peñuelas et al. (1997)
1998	PSSRA	Pigment Specific Simple Ratio for chlorophyll *a* (PSSRa)	SR	$\frac{\rho_{800}}{\rho_{680}}$	Blackburn (1998a,b)
1998	PSSRB	Pigment Specific Simple Ratio for chlorophyll *b* (PSSRb)	SR	$\frac{\rho_{800}}{\rho_{635}}$	Blackburn (1998a,b)

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Year	Code	Description	Type[1]	Formula	Citation
1998	PSSRC	Pigment Specific Simple Ratio for carotenoid (PSSRc)	SR	$\frac{\rho_{800}}{\rho_{470}}$	Blackburn (1998a,b)
1998	PSNDA	Pigment Specific Normalized Difference for chlorophyll a (PSNDa)	ND	$\frac{\rho_{800}-\rho_{680}}{\rho_{800}+\rho_{680}}$	Blackburn (1998a,b)
1998	PSNDB	Pigment Specific Normalized Difference for chlorophyll b (PSNDb)	ND	$\frac{\rho_{800}-\rho_{635}}{\rho_{800}+\rho_{635}}$	Blackburn (1998a,b)
1998	PSNDC	Pigment Specific Normalized Difference for carotenoid (PSNDc)	ND	$\frac{\rho_{800}-\rho_{470}}{\rho_{800}+\rho_{470}}$	Blackburn (1998a,b)
1998	DSR1	Datt simple ratio 1	SR	$\frac{\rho_{672}}{\rho_{550}\rho_{708}}$	Datt (1998)
1998	DSR2	Datt simple ratio 2	SR	$\frac{\rho_{672}}{\rho_{550}}$	Datt (1998)
1999	DNDR	Datt normalized difference ratio	ND	$\frac{\rho_{850}-\rho_{710}}{\rho_{850}-\rho_{680}}$	Datt (1999a,b)
1999	DDR1	Datt first derivative ratio	SF	$\frac{\rho'_{754}}{\rho'_{704}}$	Datt (1999b)
1999	DDR2	Datt second derivative ratio	SF	$\frac{\rho''_{712}}{\rho''_{688}}$	Datt (1999b)

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Year	Code	Description	Type[1]	Formula	Citation
1999	GMSR	Gamon simple ratio	SR	$\frac{\rho_{\mathrm{RED}}}{\rho_{\mathrm{GRN}}}$	Gamon and Surfus (1999)
1999	PSRI	Plant Senescence Reflectance Index (PSRI)	ND	$\frac{\rho_{678}-\rho_{500}}{\rho_{750}}$	Merzlyak et al. (1999)
2000	TVI	Triangular Vegetation Index (TVI)	EN	$0.5[120(\rho_{750}-\rho_{550})-200(\rho_{670}-\rho_{550})]$	Broge and Leblanc (2000)
2000	MCARI	Modified Chlorophyll Absorption in Reflectance Index (MCARI)	EN	$[(\rho_{700}-\rho_{670})-0.2(\rho_{700}-\rho_{550})]\left(\frac{\rho_{700}}{\rho_{670}}\right)$	Daughtry et al. (2000)
2000	MOR	MCARI OSAVI ratio	EN	$\frac{\mathrm{MCARI}}{\mathrm{OSAVI}}$	Daughtry et al. (2000)
2000	ZTSR1	Zarco-Tejada simple ratio 1	SR	$\frac{\rho_{685}}{\rho_{655}}$	Zarco-Tejada et al. (2000a,b)
2000	CI	Curvature Index (CI)	EN	$\frac{\rho_{683}^2}{\rho_{675}\rho_{691}}$	Zarco-Tejada et al. (2000a,b)
2000	ZTDR1	Zarco-Tejada derivative ratio 1	SF	$\frac{\rho'_{730}}{\rho'_{706}}$	Zarco-Tejada et al. (2000b)

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Year	Code	Description	Type[1]	Formula	Citation
2000	ZTSR2	Zarco-Tejada simple ratio 2	SR	$\frac{\rho_{750}}{\rho_{710}}$	Zarco-Tejada et al. (2000b)
2001	CAI	Cellulose Absorption Index (CAI)	EN	$0.5(\rho_{2019} + \rho_{2206}) - \rho_{2109}$	Daughtry (2001)
2001	ARI	Anthocyanin Reflectance Index (ARI)	EN	$(\rho_{550})^{-1} - (\rho_{700})^{-1}$	Gitelson et al. (2001)
2001	MND1	Maccioni normalized difference 1	ND	$\frac{\rho_{780} - \rho_{710}}{\rho_{780} - \rho_{680}}$	Maccioni et al. (2001); Datt (1999b)
2001	MND2	Maccioni normalized difference 2	ND	$\frac{\rho_{542} - \min(\rho(\lambda_{\mathrm{RED}}))}{\rho_{750} - \min(\rho(\lambda_{\mathrm{RED}}))} : 660 \leq \lambda_{\mathrm{RED}} \leq 680$	Maccioni et al. (2001)
2001	MND3	Maccioni normalized difference 3	ND	$\frac{\rho_{706} - \min(\rho(\lambda_{\mathrm{RED}}))}{\rho_{750} - \min(\rho(\lambda_{\mathrm{RED}}))} : 660 \leq \lambda_{\mathrm{RED}} \leq 680$	Maccioni et al. (2001)
2001	MND4	Maccioni normalized difference 4	ND	$\frac{\rho_{556} - \min(\rho(\lambda_{\mathrm{RED}}))}{\rho_{750} - \min(\rho(\lambda_{\mathrm{RED}}))} : 660 \leq \lambda_{\mathrm{RED}} \leq 680$	Maccioni et al. (2001)
2001	CAINT	Chlorophyll Absorption INTegral (CAINT)	SF	$\sum_{\lambda=600}^{735} \left(\frac{\rho(\lambda)}{y(\lambda)}\right) d\lambda : y(\lambda) = \frac{\rho_{735} - \rho_{600}}{\lambda_{735} - \lambda_{600}}(\lambda - 600) + \rho_{600}$	Oppelt and Mauser (2001, 2004)

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Year	Code	Description	Type[1]	Formula	Citation
2001	ZTSUM	Area of the first derivative peak from 680 nm to 760 nm	SF	$\sum_{\lambda=680}^{760} \rho'(\lambda) d\lambda$	Zarco-Tejada et al. (2001b)
2001	PRI3	Photochemical Reflectance Index 3 (PRI3)	ND	$\frac{\rho_{531} - \rho_{570}}{\rho_{531} + \rho_{570}}$	Zarco-Tejada et al. (2001b)
2001	ZTDPR1	Zarco-Tejada derivative peak ratio 1	SF	$\frac{\rho'_{\lambda_{RDE}}}{\rho'_{\lambda_{RDE}+12}}$: λ_{RDE} from WLREIPG	Zarco-Tejada et al. (2001b); Miller et al. (1990)
2001	ZTDPR2	Zarco-Tejada derivative peak ratio 2	SF	$\frac{\rho'_{\lambda_{RDE}}}{\rho'_{\lambda_{RDE}+22}}$: λ_{RDE} from WLREIPG	Zarco-Tejada et al. (2001b); Miller et al. (1990)
2001	ZTDP21	Zarco-Tejada derivative peak ratio 21	SF	$\frac{\rho'_{\lambda_{RDE}}}{\rho'_{703}}$: λ_{RDE} from WLREIPG	Zarco-Tejada et al. (2001b); Miller et al. (1990)
2001	ZTDP22	Zarco-Tejada derivative peak ratio 22	SF	$\frac{\rho'_{\lambda_{RDE}}}{\rho'_{720}}$: λ_{RDE} from WLREIPG	Zarco-Tejada et al. (2001b); Miller et al. (1990)

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Year	Code	Description	Type[1]	Formula	Citation
2001	GI	Greenness Index	SR	$\frac{\rho_{554}}{\rho_{677}}$	Zarco-Tejada et al. (2001b)
2001	ZTSR3	Zarco-Tejada simple ratio 3	SR	$\frac{\rho_{680}}{\rho_{630}}$	Zarco-Tejada et al. (2001a)
2001	ZTSR4	Zarco-Tejada simple ratio 4	SR	$\frac{\rho_{685}}{\rho_{630}}$	Zarco-Tejada et al. (2001a)
2001	ZTSR5	Zarco-Tejada simple ratio 5	SR	$\frac{\rho_{687}}{\rho_{630}}$	Zarco-Tejada et al. (2001a)
2001	ZTSR6	Zarco-Tejada simple ratio 6	SR	$\frac{\rho_{690}}{\rho_{630}}$	Zarco-Tejada et al. (2001a)
2002	VARI	Visible Atmospherically Resistant Index (VARI)	ND	$\frac{\rho_{\mathrm{GRN}} - \rho_{\mathrm{RED}}}{\rho_{\mathrm{GRN}} + \rho_{\mathrm{RED}} - \rho_{\mathrm{BLU}}}$	Gitelson et al. (2002a)
2002	CRI500	Carotenoid Reflectance Index (CRI550)	EN	$(\rho_{510})^{-1} - (\rho_{550})^{-1}$	Gitelson et al. (2002b)

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Year	Code	Description	Type[1]	Formula	Citation
2002	CRI700	Carotenoid Reflectance Index (CRI700)	EN	$(\rho_{510})^{-1} - (\rho_{700})^{-1}$	Gitelson et al. (2002b)
2002	TCARI	Transformed Chlorophyll Absorption Ratio Index (TCARI)	EN	$3\left[(\rho_{700} - \rho_{670}) - 0.2(\rho_{700} - \rho_{550})\left(\frac{\rho_{700}}{\rho_{670}}\right)\right]$	Haboudane et al. (2002)
2002	TOR	TCARI OSAVI ratio	EN	$\frac{\text{TCARI}}{\text{OSAVI}}$	Haboudane et al. (2002)
2002	EVI	Enhanced Vegetation Index (EVI)	EN	$2.5\left(\frac{\rho_{\text{NIR}} - \rho_{\text{RED}}}{\rho_{\text{NIR}} + 6\rho_{\text{RED}} - 7.5\rho_{\text{BLU}} + 1}\right)$	Huete et al. (2002)
2002	NDNI	Normalized Difference Nitrogen Index (NDNI)	EN	$\frac{\log_{10}(\rho_{1510}^{-1}) - \log_{10}(\rho_{1680}^{-1})}{\log_{10}(\rho_{1510}^{-1}) + \log_{10}(\rho_{1680}^{-1})}$	Serrano et al. (2002)
2002	NDLI	Normalized Difference Lignin Index (NDLI)	EN	$\frac{\log_{10}(\rho_{1754}^{-1}) - \log_{10}(\rho_{1680}^{-1})}{\log_{10}(\rho_{1754}^{-1}) + \log_{10}(\rho_{1680}^{-1})}$	Serrano et al. (2002)
2002	MSR2	Modified Simple Ratio 2	ND	$\frac{\rho_{750} - \rho_{445}}{\rho_{705} - \rho_{445}}$	Sims and Gamon (2002)
2002	SMNDVI	Sims Modified Normalized Difference Vegetation Index	ND	$\frac{\rho_{750} - \rho_{705}}{\rho_{750} + \rho_{705} - 2\rho_{445}}$	Sims and Gamon (2002)

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Year	Code	Description	Type[1]	Formula	Citation
2003	GRRGM	Gitelson Reciprocal Reflectance Green Model	SR	$\left(\frac{\rho_{\text{NIR}}}{\rho_{\text{GRN}}}\right) - 1$	Gitelson et al. (2003, 2005)
2003	GRRREM	Gitelson Reciprocal Reflectance Red Edge Model	SR	$\left(\frac{\rho_{\text{NIR}}}{\rho_{\text{RDE}}}\right) - 1$	Gitelson et al. (2003, 2005)
2003	DPI	Double-Peak Index (DPI)	SF	$\frac{\rho'_{688}\rho'_{710}}{\rho'^{2}_{697}}$	Zarco-Tejada et al. (2003a)
2003	SRWI	Simple Ratio Water Index (SRWI)	SR	$\frac{\rho_{860}}{\rho_{1240}}$	Zarco-Tejada et al. (2003b)
2004	MTCI	MERIS Terrestrial Chlorophyll Index (MTCI)	ND	$\frac{\rho_{754} - \rho_{709}}{\rho_{709} - \rho_{681}}$	Dash and Curran (2004)
2004	WDRVI	Wide Dynamic Range Vegetation Index (WDRVI)	EN	$\frac{a\rho_{\text{NIR}} - \rho_{\text{RED}}}{a\rho_{\text{NIR}} + \rho_{\text{RED}}} : (a = 0.15)$	Gitelson (2004)
2004	MCARI1	Modified Chlorophyll Absorption in Reflectance Index 1 (MCARI1)	EN	$1.2[2.5(\rho_{800} - \rho_{670}) - 1.3(\rho_{800} - \rho_{550})]$	Haboudane et al. (2004)

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Year	Code	Description	Type[1]	Formula	Citation
2004	MCARI2	Modified Chlorophyll Absorption in Reflectance Index 2 (MCARI2)	EN	$\frac{1.5[2.5(\rho_{800}-\rho_{670})-1.3(\rho_{800}-\rho_{550})]}{\sqrt{(2\rho_{800}+1)^2-(6\rho_{800}-5\sqrt{\rho_{670}})-0.5}}$	Haboudane et al. (2004)
2004	MTVI1	Modified Triangular Vegetation Index 1 (MTVI1)	EN	$1.2[1.2(\rho_{800}-\rho_{550})-2.5(\rho_{670}-\rho_{550})]$	Haboudane et al. (2004)
2004	MTVI2	Modified Triangular Vegetation Index 2 (MTVI2)	EN	$\frac{1.5[1.2(\rho_{800}-\rho_{550})-2.5(\rho_{670}-\rho_{550})]}{\sqrt{(2\rho_{800}+1)^2-(6\rho_{800}-5\sqrt{\rho_{670}})-0.5}}$	Haboudane et al. (2004)
2004	DD	Double Difference index (DD)	DF	$(\rho_{749}-\rho_{720})-(\rho_{701}-\rho_{672})$	Le Maire et al. (2004)
2005	LCA	Lignin Cellulose Absorption Index (LCA)	EN	$100[(\rho_{2205}-\rho_{2165})+(\rho_{2205}-\rho_{2330})]$	Daughtry et al. (2005)
2005	RGI	Red Green Pigment Index (RGI)	SR	$\frac{\rho_{690}}{\rho_{550}}$	Zarco-Tejada et al. (2005)
2005	BGI1	Blue Green Pigment Index 1 (BGI1)	SR	$\frac{\rho_{400}}{\rho_{550}}$	Zarco-Tejada et al. (2005)
2005	BGI2	Blue Green Pigment Index 2 (BGI2)	SR	$\frac{\rho_{450}}{\rho_{550}}$	Zarco-Tejada et al. (2005)

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Year	Code	Description	Type[1]	Formula	Citation
2005	BRI1	Blue Red Pigment Index 1 (BRI1)	SR	$\frac{\rho_{400}}{\rho_{690}}$	Zarco-Tejada et al. (2005)
2005	BRI2	Blue Red Pigment Index 2 (BRI2)	SR	$\frac{\rho_{450}}{\rho_{690}}$	Zarco-Tejada et al. (2005)
2006	WLREIPE	Wavelength of red edge inflection point, extrapolation method	SF	$\lambda_{\mathrm{RDE}} = \frac{-(c_1 - c_2)}{m_1 - m_2} : \rho'_1(\lambda) = m_1\lambda + c_1, \rho'_2(\lambda) = m_2\lambda + c_2, m_1 = \frac{\rho'_{700} - \rho'_{680}}{\lambda_{700} - \lambda_{680}}, m_2 = \frac{\rho'_{760} - \rho'_{725}}{\lambda_{760} - \lambda_{725}}$	Cho and Skidmore (2006)
2006	RVIOPT	Reyniers VIopt	EN	$(1 + 0.45)\frac{\rho_{\mathrm{NIR}}^2 + 1}{\rho_{\mathrm{RED}} + 0.45}$	Reyniers et al. (2006)
2006	SPVI	Spectral Polygon Vegetation Index (SPVI)	EN	$0.4[3.7(\rho_{800} - \rho_{670}) - 1.2\lvert\rho_{550} - \rho_{670}\rvert]$	Vincini et al. (2006)
2007	MMR	MCARI MTVI2 ratio	EN	$\frac{\mathrm{MCARI}}{\mathrm{MTVI2}}$	Eitel et al. (2007)
2008	TCI	Triangular Chlorophyll Index (TCI)	EN	$1.2(\rho_{700} - \rho_{550}) - 1.5(\rho_{670} - \rho_{550})\sqrt{\frac{\rho_{700}}{\rho_{670}}}$	Haboudane et al. (2008)
2008	EVI2	Enhanced Vegetation Index 2 (EVI2)	EN	$\frac{2.5(\rho_{\mathrm{NIR}} - \rho_{\mathrm{RED}})}{\rho_{\mathrm{NIR}} + 2.4\rho_{\mathrm{RED}} + 1}$	Jiang et al. (2008)

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Year	Code	Description	Type[1]	Formula	Citation
2008	DDN	New Double Difference index (DDN)	DF	$2\rho_{710} - \rho_{660} - \rho_{760}$	Le Maire et al. (2008)
2008	CVI	Chlorophyll Vegetation Index (CVI)	EN	$\frac{\rho_{\mathrm{NIR}}\rho_{\mathrm{RED}}}{\rho^2_{\mathrm{GRN}}}$	Vincini et al. (2008)
2008	WUTCARI	Transformed Chlorophyll Absorption Ratio Index [705, 750]	EN	$3\left[(\rho_{750} - \rho_{705}) - 0.2(\rho_{750} - \rho_{550})\left(\frac{\rho_{750}}{\rho_{705}}\right)\right]$	Wu et al. (2008)
2008	WUOSAVI	Optimized Soil-Adjusted Vegetation Index [705, 750]	SA	$(1+L)\left(\frac{\rho_{750} - \rho_{705}}{\rho_{750} + \rho_{705} + L}\right) : (L = 0.16)$	Wu et al. (2008)
2008	WUMCARI	Modified Chlorophyll Absorption in Reflectance Index [705, 750]	EN	$[(\rho_{750} - \rho_{705}) - 0.2(\rho_{750} - \rho_{550})]\left(\frac{\rho_{750}}{\rho_{705}}\right)$	Wu et al. (2008)
2008	WUMSR	Modified Simple Ratio [705, 750]	EN	$\frac{\rho_{750}/\rho_{705} - 1}{\sqrt{\rho_{750}/\rho_{705} + 1}}$	Wu et al. (2008)
2008	WUTOR	TCARI OSAVI ratio [705, 750]	EN	$\frac{\mathrm{WUTCARI}}{\mathrm{WUOSAVI}}$	Wu et al. (2008)
2008	WUMOR	MCARI OSAVI ratio [705, 750]	EN	$\frac{\mathrm{WUMCARI}}{\mathrm{WUOSAVI}}$	Wu et al. (2008)
2010	DCNI	Double-peak Canopy Nitrogen Index (DCNI)	SF	$\frac{\left(\frac{\rho_{720} - \rho_{700}}{\rho_{700} - \rho_{670}}\right)}{\rho_{720} - \rho_{670} + 0.03}$	Chen et al. (2010)

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Table 1 – Continued from previous page

Year	Code	Description	Type[1]	Formula	Citation
2011	TGI	Triangular Greenness Index (TGI)	EN	$-0.5[(\lambda_{\mathrm{RED}} - \lambda_{\mathrm{BLU}})(\rho_{\mathrm{RED}} - \rho_{\mathrm{GRN}}) - (\lambda_{\mathrm{RED}} - \lambda_{\mathrm{GRN}})(\rho_{\mathrm{RED}} - \rho_{\mathrm{BLU}})]$	Hunt et al. (2011)
2011	WDRVI2	Wide Dynamic Range Vegetation Index 2 (WDRVI2)	EN	$\frac{\alpha\rho_{\mathrm{NIR}} - \rho_{\mathrm{RED}}}{\alpha\rho_{\mathrm{NIR}} + \rho_{\mathrm{RED}}} + \frac{1-\alpha}{1+\alpha} : (\alpha = 0.2)$	Peng and Gitelson (2011)
2016	AIVI	Angular Insensitivity Vegetation Index (AIVI)	EN	$\frac{\rho_{445}(\rho_{720} + \rho_{735}) - \rho_{573}(\rho_{720} - \rho_{735})}{\rho_{720}(\rho_{573} + \rho_{445})}$	He et al. (2016)
2017	DND	Derivative Normalized Difference	SF	$\frac{\rho'_{522} - \rho'_{728}}{\rho'_{522} + \rho'_{728}}$	Sonobe and Wang (2017)

1 Types of spectral vegetation indices include the following: simple ratio (SR), difference (DF), normalized difference (ND), soil-adjusted (SA), spectral feature (SF), and enhanced (EN).

Table 2: Additional information for each spectral vegetation index (indicated by its year and code from Table 1), including the evaluated plant species, the scale of the remote sensing data, and the evaluated dependent variables. Information was collected only from the original publication(s) for each spectral index as cited, and use of indices for other plant species and dependent variables can likely be found with further literature review.

Year	Code	Plant Species[1]	Scale	Dependent Variables[2]	Citation
1968	BRSR	Kentucky bluegrass, tall fescue, colonial bentgrass	canopy	visual color scores	Birth and McVey (1968)
1969	JSR	forest canopy	canopy	LAI, Chl *a*	Jordan (1969)
1973	NDVI	*Stipa* and *Bouteloua* genera, rangeland grasses including warm-season grasses (blue grama, buffalograss, sideoats grama, big and little bluestem) and cool-season grasses (western wheatgrass, needle-and-thread, Texas wintergrass)	canopy	green and dry biomass	Rouse et al. (1973)
1977	PVI	sorghum	canopy	crop cover and height, LAI	Richardson and Wiegand (1977)
1978	WLREIP	wheat, alfalfa, cotton, sugar beet, sudan grass, milo, pea, maize, sunflower, silver birch, ash, hawthorn, pendunculate oak, winter and spring barley, winter wheat	canopy	Chl	Collins (1978); Horler et al. (1983)
1979	DVI, NDVI2	blue grama grass	canopy	wet and dry biomass, leaf water content, Chl	Tucker (1979)
1988	WLREIP2	maize, rye, mixed grass (*Brachypodium genuense*, quaking-grass, erect brome, *Festuca* species) and herb (snow carpet, *Cirsium creticum*, pygmy hawksbeard, *Lamium garganicum*, common sainfoin, feverfew, red clover)	leaf, canopy	leaf N	Guyot and Baret (1988); Cho and Skidmore (2006)

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Year	Code	Plant Species[1]	Scale	Dependent Variables[2]	Citation
1988	SAVI	cotton, Lehmann lovegrass	canopy	LAI	Huete (1988)
1989	TSAVI	wheat	canopy	LAI, APAR	Baret et al. (1989)
1989	WDVI	barley	canopy	LAI	Clevers (1989)
1989	MSI	California live oak, blue spruce, sweetgum, red spruce, soybean	leaf	leaf relative water content, equivalent water thickness	Hunt and Rock (1989)
1990	BD, BDR	sugar beet, wheat	canopy	plant species, cultivar, N fertilizer rate, sowing date	Boochs et al. (1990)
1990	SAVI2	wheat	canopy	LAI	Major et al. (1990)
1990	WLREIPG, WLCWMRG	burr oak, sugar maple, balsom fir, American beech, black spruce	leaf	none	Miller et al. (1990)
1991	TSAVI2	none	canopy	LAI	Baret and Guyot (1991)
1992	CPSR1	soybean	leaf	Chl *a*	Chappelle et al. (1992)
1992	CPSR2	soybean	leaf	Chl *b*	Chappelle et al. (1992)
1992	CPSR3	soybean	leaf	carotenoid	Chappelle et al. (1992)
1992	PRI	sunflower	leaf, canopy	xanthophyll epoxidation state, photosynthetic efficiency	Gamon et al. (1992)
1992	GEMI	none	canopy	none	Pinty and Verstraete (1992)

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Year	Code	Plant Species[1]	Scale	Dependent Variables[2]	Citation
1993	BMSR, BMLSR, BMDVI	bean	leaf	Chl $a + b$	Buschmann and Nagel (1993)
1993	PSR, PD, WLPD	gerbera, pepper, bean	canopy	leaf relative water content, leaf water potential, leaf conductance, photosynthetic rate	Peñuelas et al. (1993)
1993	VSR, VDR	sugar maple	leaf	Chl $a + b$	Vogelmann et al. (1993)
1994	CRSR1, CRSR2, CRSR3, CRSR4, CRSR5	persimmon, loblolly pine, slash pine, switchcane, golden euonymus, live oak	leaf	physiochemical & biological stress	Carter (1994)
1994	FSUM, DREIP	gerbera, pepper, bean, wheat	canopy	LAI, Chl	Filella and Peñuelas (1994); Filella et al. (1995)
1994	NDVI3, GSUM1, GSUM2	horse chestnut, Norway maple	leaf	Chl a	Gitelson and Merzlyak (1994)
1994	NLI	aspen, corn	canopy	LAI, fPAR	Goel and Qin (1994)
1994	CAR	soybean	leaf	Chl a	Kim et al. (1994)
1994	CARI	soybean	canopy	fPAR, LAI	Kim et al. (1994)
1994	NPCI	sunflower	leaf	Chl, leaf N, net CO_2 uptake, light use efficiency, leaf thickness, leaf starch	Peñuelas et al. (1994)
1994	EGFN	sunflower	leaf	Chl, leaf N	Peñuelas et al. (1994)

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Year	Code	Plant Species[1]	Scale	Dependent Variables[2]	Citation
1994	MSAVI1, MSAVI2	cotton	canopy	% green cover	Qi et al. (1994)
1995	ESUM1, ESUM2	pinyon pine	canopy	LAI, % green cover	Elvidge and Chen (1995)
1995	NDPI, SIPI	maize, wheat, tomato, soybean, sunflower, sugar beet, oak, boxelder maple, succulent	leaf	carotenoid:Chl a (ratio)	Peñuelas et al. (1995a)
1995	SRPI	apple	canopy	carotenoid:Chl a (ratio)	Peñuelas et al. (1995b)
1995	NPQI	apple	canopy	Chl	Peñuelas et al. (1995b)
1995	RDVI	none	canopy	fPAR	Roujean and Breon (1995)
1996	MSR	jack pine, black spruce	canopy	LAI, fPAR	Chen (1996)
1996	PRI2	barley	canopy	xanthophyll epoxidation state, zeaxanthin, photosynthetic efficiency	Filella et al. (1996)
1996	NDWI	unspecified woodland, grassland, and crop species	canopy	vegetation liquid water	Gao (1996)
1996	GTSR1, GTSR2	horse chestnut, Norway maple, tobacco, fig, oleander, hibiscus, common grape vine, rose	leaf	Chl $a+b$, Chl a	Gitelson and Merzlyak (1996, 1997); Lichtenthaler et al. (1996)
1996	GNDVI	horse chestnut, Norway maple	leaf	Chl $a+b$, Chl a	Gitelson et al. (1996)
1996	OSAVI	none	canopy	foliage cover	Rondeaux et al. (1996)

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Year	Code	Plant Species[1]	Scale	Dependent Variables[2]	Citation
1997	WI, WNR	kermes oak, strawberry tree, grey-leaved cistus, Montpellier cistus, Mediterranean false brome, Aleppo pine, evergreen oak, narrow-leaved mock privet, mastic tree	canopy	plant water concentration	Peñuelas et al. (1997)
1998	PSSRA, PSNDA	bracken, beech, oak, boxelder maple, sweet chestnut	leaf	Chl a	Blackburn (1998a,b)
1998	PSSRB, PSNDB	bracken, beech, oak, boxelder maple, sweet chestnut	leaf	Chl b	Blackburn (1998a,b)
1998	PSSRC, PSNDC	bracken, beech, oak, boxelder maple, sweet chestnut	leaf	carotenoid	Blackburn (1998a,b)
1998	DSR1, DSR2	*Eucalyptus* species	leaf	Chl a, Chl b, Chl $a+b$, carotenoid	Datt (1998)
1999	DNDR, DDR1, DDR2	*Eucalyptus* species	leaf	Chl a, Chl $a+b$	Datt (1999a,b)
1999	GMSR	Douglas fir, coast live oak, sunflower	leaf	anthocyanin	Gamon and Surfus (1999)
1999	PSRI	Norway maple, horse chestnut, potato, coleus	leaf	Chl, carotenoid:Chl (ratio)	Merzlyak et al. (1999)
2000	TVI	none	canopy	Chl $a+b$, LAI	Broge and Leblanc (2000)
2000	MCARI, MOR	corn	leaf, canopy	Chl $a+b$, LAI	Daughtry et al. (2000)
2000	ZTSR1, ZTSR2, CI, ZTDR1	sugar maple	leaf, canopy	fluorescence	Zarco-Tejada et al. (2000a,b)
2001	CAI	corn, soybean, wheat	canopy	residue cover	Daughtry (2001)

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Year	Code	Plant Species[1]	Scale	Dependent Variables[2]	Citation
2001	ARI	Norway maple, cotoneaster, dogwood, pelargonium	leaf	anthocyanin	Gitelson et al. (2001)
2001	MND1	croton, spotted elaeagnus, Japanese pittosporum, Benjamin fig	leaf	Chl $a+b$, Chl a, Chl b	Maccioni et al. (2001)
2001	MND2	croton, spotted elaeagnus, Japanese pittosporum, Benjamin fig	leaf	Chl $a+b$	Maccioni et al. (2001)
2001	MND3	croton, spotted elaeagnus, Japanese pittosporum, Benjamin fig	leaf	Chl a	Maccioni et al. (2001)
2001	MND4	croton, spotted elaeagnus, Japanese pittosporum, Benjamin fig	leaf	Chl b	Maccioni et al. (2001)
2001	CAINT	maize, wheat	canopy	leaf N, Chl $a+b$, Chl a, Chl b	Oppelt and Mauser (2001, 2004)
2001	ZTSUM, ZTDPR1, ZTDPR2, ZTDP21, ZTDP22, PRI3, GI	sugar maple	leaf, canopy	Chl $a+b$	Zarco-Tejada et al. (2001b)
2001	ZTSR3, ZTSR4, ZTSR5, ZTSR6	sugar maple	leaf, canopy	fluorescence	Zarco-Tejada et al. (2001a)
2002	VARI	wheat	canopy	vegetation fraction	Gitelson et al. (2002a)
2002	CRI500, CRI700	Norway maple, horse chestnut, beech	leaf	Chl, carotenoid	Gitelson et al. (2002b)
2002	TCARI, TOR	corn	leaf, canopy	Chl	Haboudane et al. (2002)
2002	EVI	grass/shrub, savanna, and tropical forest biomes	canopy	LAI	Huete et al. (2002)

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Year	Code	Plant Species[1]	Scale	Dependent Variables[2]	Citation
2002	NDNI	ceanothus chapparal (*Ceanothus* species), chamise chaparral, coastal sage scrub (*Salvia* species, *Eriogonum* species, California sagebrush)	canopy	leaf and canopy N	Serrano et al. (2002)
2002	NDLI	ceanothus chapparal (*Ceanothus* species), chamise chaparral, coastal sage scrub (*Salvia* species, *Eriogonum* species, California sagebrush)	canopy	leaf and canopy lignin	Serrano et al. (2002)
2002	MSR2, SMNDVI	53 plant species	leaf	Chl	Sims and Gamon (2002)
2003	GRRGM, GRRREM	Norway maple, horse chestnut, beech, wild vine shrub, maize, soybean	leaf	Chl	Gitelson et al. (2003, 2005)
2003	DPI	boxelder maple	canopy	fluorescence	Zarco-Tejada et al. (2003a)
2003	SRWI	various chapparal species (chamise, redshanks, California sagebrush, bigpod ceanothus, greenbark, San Luis purple sage, Californian black sage)	canopy	leaf water content	Zarco-Tejada et al. (2003b)
2004	MTCI	Douglas fir, bigleaf maple	canopy	Chl	Dash and Curran (2004)
2004	WDRVI	wheat, soybean, maize	canopy	LAI, vegetation fraction	Gitelson (2004)
2004	MCARI1, MCARI2, MTVI1, MTVI2	corn, wheat, soybean	leaf, canopy	LAI	Haboudane et al. (2004)
2004	DD	sycamore, *Betula species*, European beech, ash, wild cherry, oak, evergreen oak, *Salix* species	leaf	Chl	Le Maire et al. (2004)

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Year	Code	Plant Species[1]	Scale	Dependent Variables[2]	Citation
2005	LCA	corn, soybean, wheat, tall fescue, alfalfa	canopy	residue cover	Daughtry et al. (2005)
2005	RGI, BGI1, BGI2, BRI1, BRI2	common grape vine	leaf, canopy	Chl $a+b$, Chl a, Chl b	Zarco-Tejada et al. (2005)
2006	WLREIPE	maize, rye, mixed grass (*Brachypodium genuense*, quaking-grass, erect brome, *Festuca* species) and herb (snow carpet, *Cirsium creticum*, pygmy hawksbeard, *Lamium garganicum*, common sainfoin, feverfew, red clover)	leaf, canopy	leaf N	Cho and Skidmore (2006)
2006	RVIOPT	winter wheat	canopy	plant N	Reyniers et al. (2006)
2006	SPVI	maize, sugar beet	canopy	Chl, LAI	Vincini et al. (2006)
2007	MMR	spring wheat	canopy	SPAD meter, leaf N	Eitel et al. (2007)
2008	TCI	corn, wheat, bean, pea	canopy	Chl, LAI	Haboudane et al. (2008)
2008	EVI2	none	canopy	none	Jiang et al. (2008)
2008	DDN	oak, sessile oak, Scots pine, beech	canopy	Chl	Le Maire et al. (2008)
2008	CVI	sugar beet	canopy	Chl $a+b$	Vincini et al. (2008)
2008	WUTCARI, WUOSAVI, WUMCARI, WUMSR, WUTOR, WUMOR	wheat, corn	canopy	Chl, LAI	Wu et al. (2008)
2010	DCNI	wheat, corn	canopy	plant N, LAI	Chen et al. (2010)
2011	TGI	corn, soybean, sorghum, dandelion, sweetgum, tuliptree, small-leaf linden, wheat	leaf, canopy	Chl $a+b$, SPAD meter, LAI	Hunt et al. (2011)

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Year	Code	Plant Species[1]	Scale	Dependent Variables[2]	Citation
2011	WDRVI2	maize, soybean, wheat, oat	canopy	gross primary productivity	Peng and Gitelson (2011)
2016	AIVI	winter wheat	canopy	leaf N	He et al. (2016)
2017	DND	29+ deciduous species	leaf	Chl	Sonobe and Wang (2017)

1 Scientific names for plant species are as follows: Aleppo pine, *Pinus halepensis*; alfalfa, *Medicago sativa*; American beech, *Fagus grandifolia*; apple, *Malus domestica*; ash, *Fraxinus excelsior*; aspen, *Populus tremula*; balsom fir, *Abies balsamea*; barley, *Hordeum vulgare*; bean, *Phaseolus vulgaris*; beech, *Fagas sylvatica*; Benjamin fig, *Ficus benjamina*; big bluestem, *Andropogon gerardi*; bigleaf maple, *Acer macrophyllum*; bigpod ceanothus, *Ceanothus megacarpus*; black spruce, *Picea mariana*; blue grama grass, *Bouteloua gracilis*; blue spruce, *Picea pungens*; boxelder maple, *Acer negundo*; bracken, *Pteridium aquilinum*; buffalograss, *Bouteloua dactyloides*; burr oak, *Quercus macrocarpa*; California live oak, *Quercus agrifolia*; Californian black sage, *Salvia mellifera*; California sagebrush, *Artemisia californica*; chamise chaparral, *Adenostoma fasciculatum*; coast live oak, *Quercus agrifolia*; coleus, *Coleus blumei*; colonial bentgrass, *Argrostis tenuis*; common grape vine, *Vitis vinifera*; common sainfoin, *Onobrychis viciifolia*; corn, *Zea mays*; cotoneaster, *Cotoneaster alaunica*; cotton, *Gossypium hirsutum*; croton, *Codiaeum variegatum*; dandelion, *Taraxacum officinale*; dogwood, *Cornus alba*; Douglas fir, *Pseudotsuga menziesii*; erect brome, *Bromus erectus*; European beech, *Fagus sylvatica*; evergreen oak, *Quercus ilex*; feverfew, *Tanacetum parthenium*; fig, *Ficus carica*; gerbera, *Gerbera jamesonii*; golden euonymus, *Euonymus japonica*; greenbark, *Ceanothus spinosus*; grey-leaved cistus, *Cistus albidus*; hawthorn, *Crataegus monogyna*; hibiscus, *Hibiscus esculentus*; horse chestnut, *Aesculus hippocastanum*; jack pine, *Pinus banksiana*; Japanese pittosporum, *Pittosporum tobira*; Kentucky bluegrass, *Poa protensis*; kermes oak, *Quercus coccifera*; Lehmann lovegrass, *Eragrostis lehmanniana*; little bluestem, *Schizachyrium scoparium*; live oak, *Quercus virginiana*; loblolly pine, *Pinus taeda*; maize, *Zea mays*; mastic tree, *Pistacia lentiscus*; Mediterranean false brome, *Brachypodium retusum*; milo, *Sorghum bicolor*; Montpellier cistus, *Cistus monspeliensis*; narrow-leaved mock privet, *Phillyrea angustifolia*; needle-and-thread, *Hesperostipa comata*; Norway maple, *Acer platanoides*; oak, *Quercus rober*; oleander, *Netrium oleander*; pea, *Pisum sativum*; pelargonium, *Pelargonium zonale*; pendunculate oak, *Quercus robur*; pepper, *Capsicum annuum*; persimmon, *Diospyros virginiana*; pinyon pine, *Pinus edulis*; potato, *Solanum tuberosum*; pygmy hawksbeard, *Crepis pygmaea*; quaking-grass, *Briza media*; red clover, *Trifolium pratense*; redshanks, *Adenostoma sparsifolium*; red spruce, *Picea rubens*; rose, *Rosa rugosa*; rye, *Secale cereale*; San Luis purple sage, *Salvia leucophylla*; Scots pine, *Pinus sylvestris*; sessile oak, *Quercus petraea*; sideoats grama, *Bouteloua curtipendula*; silver birch, *Betula pendula*; slash pine, *Pinus elliotti*; small-leaf linden, *Tilia cordata*; snow carpet, *Anthemis carpatica*; sorghum, *Sorghum bicolor*; soybean, *Glycine max*; spring barley, *Hordeum vulgare*; spring wheat, *Triticum aestivum*; spotted elaeagnus, *Elaeagnus pungens*; strawberry tree, *Arbutus unedo*; succulent, *Othonnopsis cheirifolia*; sudan grass, *Sorghum × drummondii*; sugar beet, *Beta vulgaris*; sugar maple, *Acer saccharum*; sunflower, *Helianthus annuus*; sweet chestnut, *Castanea sativa*; sweetgum, *Liquidambar styraciflua*; switchcane, *Arundinaria gigantea*; sycamore, *Acer pseudoplatanus*; tall fescue, *Lolium arundinaceum*; Texas wintergrass, *Nassella leucotricha*; tobacco, *Nicotiana tabacum*; tomato, *Lycopersicon esculentum*; tuliptree, *Liriodendron tulipifera*; western wheatgrass, *Pascopyrum smithii*; wheat, *Triticum aestivum*; wild cherry, *Prunus avium*; wild vine shrub, *Parthenocissus tricuspidata*; winter barley, *Hordeum vulgare*; winter wheat, *Triticum aestivum*

2 Abbreviations for dependent variables are as follows: absorbed photosynthetically active radiation, APAR; chlorophyll, Chl; fraction of photosynthetically active radiation absorbed, fPAR; leaf area index, LAI; nitrogen, N.

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