Supporting Information for

Seasonal variation in landcover estimates reveals sensitivities and opportunities for environmental models

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Introduction

This supporting information includes supplementary tables and figures from the study. These include diagrams of the modeling approach, background landcover and study area information, model parameters, and the landcover lookup table for the SWAT model.

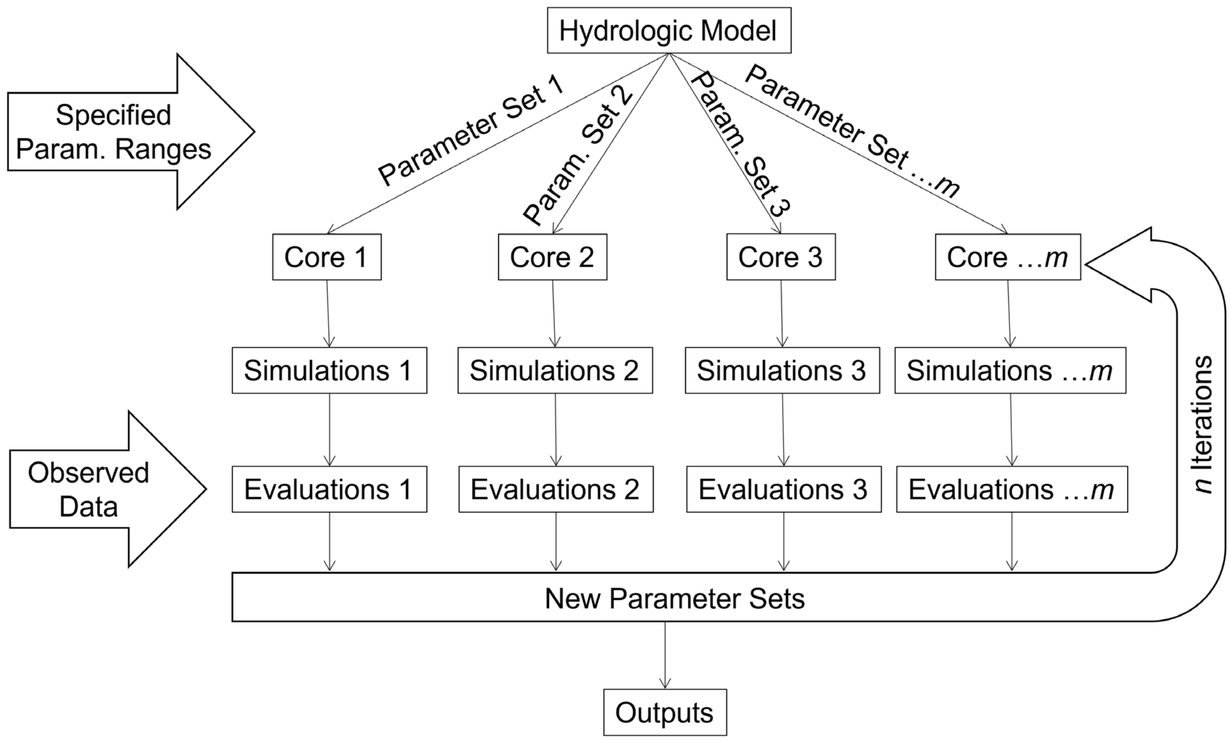

Figure S1. Flowchart of the AMALGAM calibration approach used in this study. Parameter sets are randomly generated within specified reasonable ranges of parameter values. Then, hydrologic models are distributed among multiple computer processing cores, simulations are run, and outputs are evaluated for performance against observed streamflow data. The algorithm learns from these outputs and generates new sets of parameter values. This process is iterated and optimal parameter sets are identified based on model evaluations.

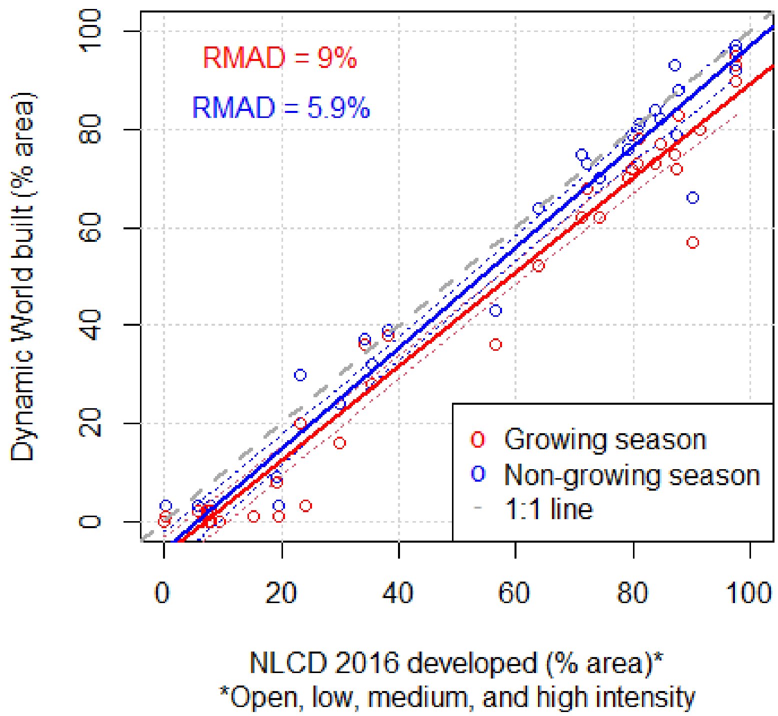

Figure S2. Comparison of Dynamic World 2016 built class and National Land Cover Database (NLCD) developed classes as proportions of watershed area for the 37 currently monitored study watersheds, with 95% confidence intervals as dotted lines. RMAD: Relative mean absolute difference.

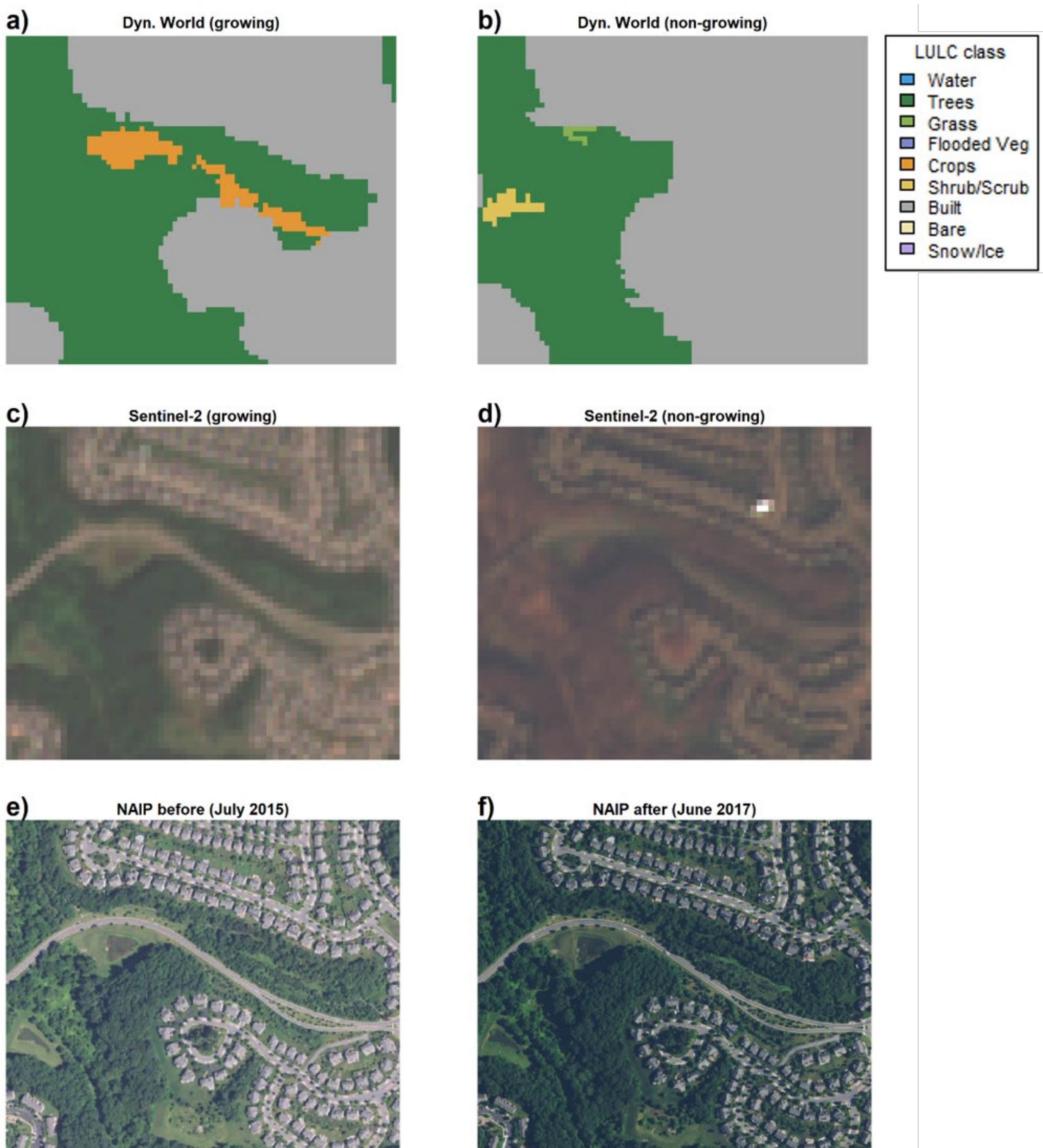

Figure S3. Visual comparison of LULC classification in a mixed landuse area of Maryland, USA showing (a,b) differences in Dynamic World data between growing (spring equinox 2016 to autumn equinox 2016) and non-growing (autumn equinox 2015 to spring equinox 2016) seasons. (c,d) Sentinel-2 imagery examples for growing (20 July, 2016) and non-growing (23 November, 2015) seasons. And, (e,f) before-and-after images from the National Agriculture Imagery Program (NAIP).

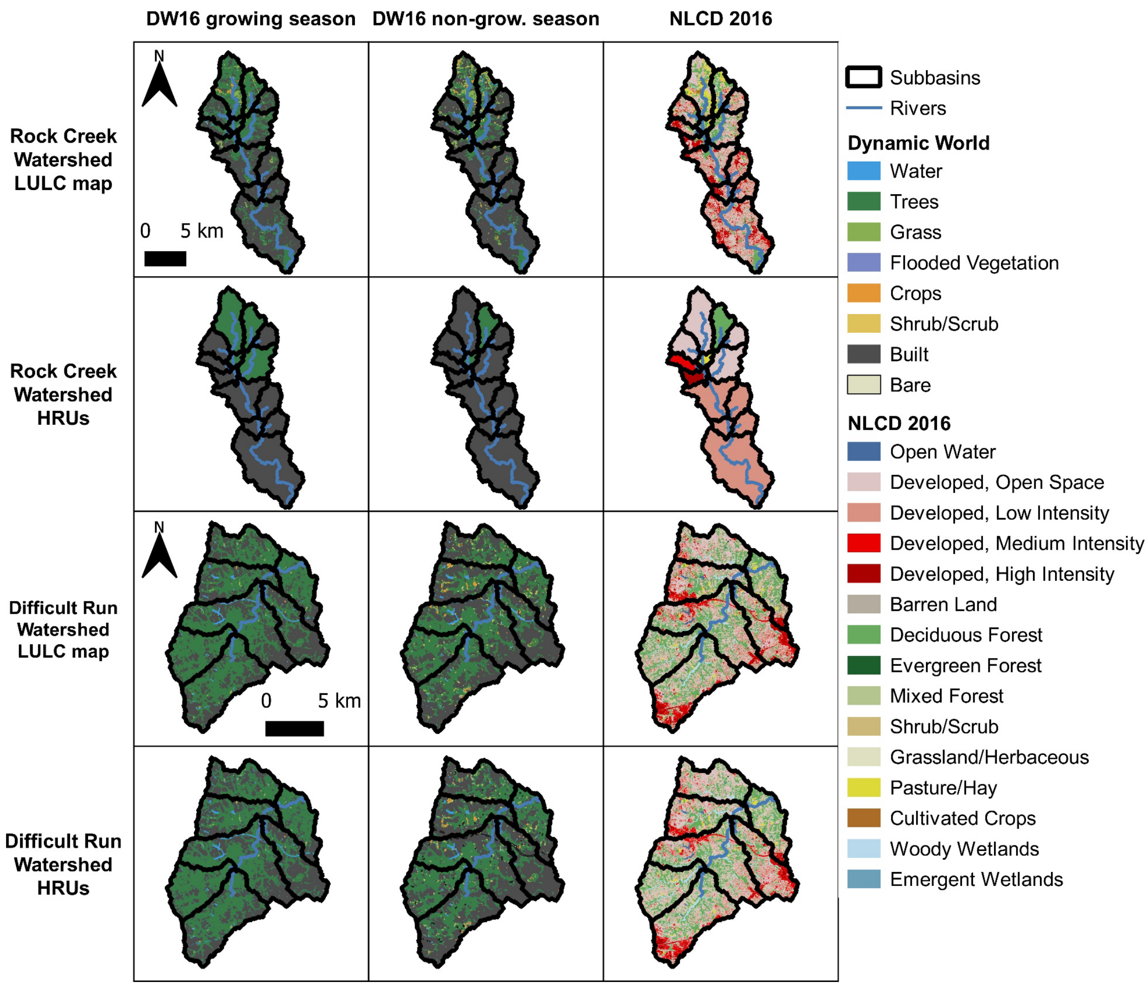

Figure S4. Delineated hydrologic response units (HRUs) for the Rock Creek Watershed (Case #2; top two rows) and Difficult Run Watershed (Case #3; bottom two rows). Rows show the input LULC data for each watershed and the resulting HRUs, while columns differentiate Dynamic World 2016 (DW16) growing and non-growing seasons and NLCD 2016. HRU numbers for Rock Creek were 13 for each LULC input, as each subbasin was assigned the dominant combination of LULC, soils, and slopes. HRU numbers for Difficult Run (which used the maximum HRU number approach) were 43 for Dynamic World 2016 growing season, 48 for Dynamic World 2016 non-growing season, and 111 for NLCD 2016 input.

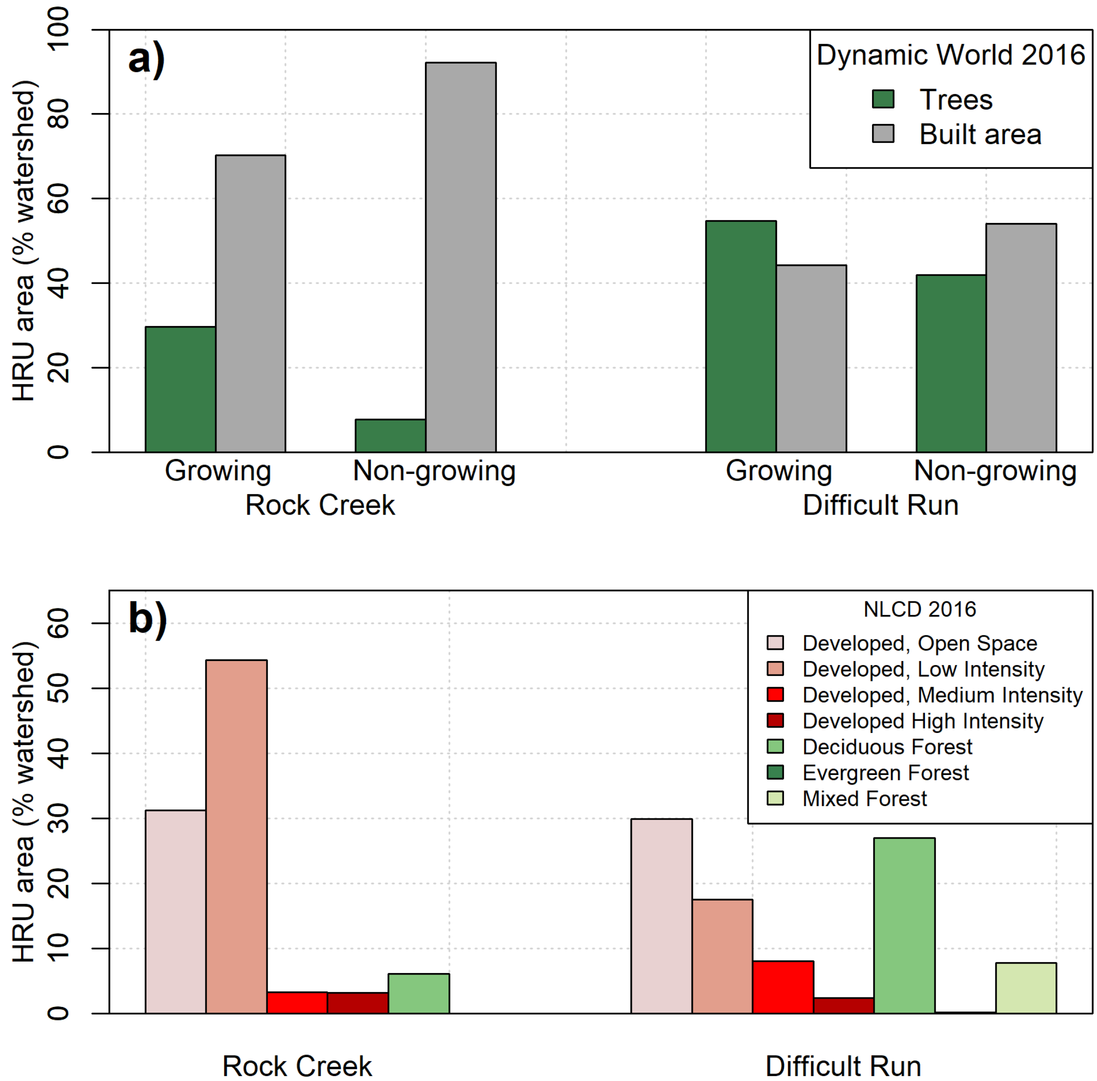

Figure S5. a) Proportions of HRU area being populated with Dynamic World 2016 trees and built area classes for the Rock Creek and Difficult Run Watersheds, split between growing and non-growing season inputs, and b) Proportions of HRU area being populated with NLCD 2016 developed and forest classes. All other HRU LULC assignments combined made up 0-4% of each watershed for Dynamic World inputs, and 2-7% of each watershed for NLCD inputs. For Rock Creek (dominant HRU approach), there was a difference in HRUs populated with Dynamic World 2016 trees class of 21.8% between growing and non-growing seasons, while that difference was 12.8% for Difficult Run (maximum HRU approach).

Table S1. Datasets and sources used in model development and comparison. USGS: United States Geological Survey. NOAA: United States National Oceanic and Atmospheric Administration.

Dataset	Source	Citation
LULC	Dynamic World	(Brown et al., 2022)
LULC	National Landcover Database 2016	(Jin et al., 2019)
Specific conductance	National Capital Region Network	(Norris et al., 2011)
Watersheds	USGS Streamstats and Whitebox Tools	(Lindsay, 2022; Ries et al., 2017)
Elevation	3DEP 30 m DEM	(Sugarbaker et al., 2014)
Soils	Global Soil Database	(Abbaspour et al., 2019)
Streams	WWF HydroSHEDS	(Lehner et al., 2006)
Daily precipitation and air temperature	NOAA weather station USW00093738	(Leeper et al., 2015)
Daily precipitation and air temperature	GridMET	(Abatzoglou, 2013)
Observed streamflow and nitrate-nitrite-nitrogen	USGS NWIS stations 01648010 and 01646000	(USGS, 2022)

Table S2. This LULC lookup table can be read into the QSWAT model so that SWAT uses the Dynamic World LULC image as the LULC input.

LANDUSE_ID	SWAT_CODE
0	WATR
1	FRST
2	RNGE
3	WETL
4	AGRL
5	RNGB
6	UCOM
7	SWRN
8	WATR

Table S3. Parameters used in SWAT model streamflow and nitrate-nitrite-nitrogen calibration for Rock Creek Watershed (Case #2), for models input with growing and non-growing season Dynamic World 2016 data, as well as the model with NLCD 2016 input.

Symbol	Definition †	Lower Limit	Upper Limit	Calibrated
CH_K2.rte	Channel hydraulic conductivity (mm/hour) (v)	0.1	150	113
ALPHA_BNK.rte	Bank flow recession constant (v)	0.01	1	0.91
CN2.mgt	Runoff curve number (r)	-0.25	0.25	-0.15
N_UPDIS.bsn	Nitrogen update distribution parameter (v)	0	30	20.7
LAT_TTIME.hru	Lateral flow travel time in days (v)	0.01	180	90
SFTMP.bsn	Snowfall temperature threshold °C (v)	0	3	1.87
CH_N2.rte	Manning's n value for main channel (v)	0.01	0.30	0.10
NPERCO.bsn	Nitrogen percolation coefficient (v)	0.01	1	0.14
CDN.bsn	Denitrification exponential rate coefficient (v)	0	3	0.05
SDNCO.bsn	Denitrification threshold water constant (v)	0	1.1	0.33

† A 'v' indicates that the original parameter from QSWAT was replaced by the calibrated value, in the same unit. An 'r' indicates that the original parameter was modified relatively, multiplying it by 1 + the calibrated value (e.g. a value of -0.2 reduces the original parameter by 20%).

Table S4. Further explanations of SWAT model parameters mentioned in Table 1 of the text for the Difficult Run Watershed. Readers are directed to Arnold et al. (2013) for additional documentation.

Symbol	Definition	Description
CH_KII.rte	Channel hydraulic conductivity (mm/h) (v)	Effective hydraulic conductivity for alluvium in the main channel of the reach, describing relationships with groundwater.
ALPHA_BNK.rte	Bank flow recession constant (v)	Regulates bank flow to the reach using a recession constant.
CN_F.mgt	Runoff curve number (r)	Representation of soil permeability, landscape characteristics, and antecedent moisture conditions.
SNO50COV.bsn	Fraction of SNOCOVMX for 50% cover (v)	Fraction of complete snow cover which represents 50% snow cover in areal depletion curve.
ESCO.hru	Soil evaporation compensation coef. (v)	Modification to soil evaporative demand at different depths.
CH_NII.rte	Manning's n value for main channel (v)	Roughness coefficient for the main channel of the reach.
SOL_BD.sol	Soil moist bulk density (r)	Ratio of oven dry soil mass to total volume near field capacity.
SNOCOVMX.bsn	Snow depth above which is 100% cover (mm) (v)	Amount of snowpack needed for complete areal coverage.
SFTMP.bsn	Snowfall temperature threshold (°C) (v)	Temperature threshold that distinguishes snowfall from rainfall during a precipitation event.
SOL_AWC.sol	Available Water Capacity (r)	Plant available water capacity of the soil.

Table S5. Proportions of watershed area that were built or developed, agricultural (crops or pasture/hay), or forested LULC categories for the Rock Creek Watershed (Case #2) and Difficult Run Watershed (Case #3).

LULC type	Rock Creek (% area)	Difficult Run (% area)
Dyn. World 2016 growing season built	57	44
Dyn. World 2016 non-growing season built	66	54
NLCD 2016 open space developed	29	30
NLCD 2016 low intensity developed	26	17
NLCD 2016 medium intensity developed	10	8
NLCD 2016 high intensity developed	5	3
Dyn. World 2016 growing season crops	0	0
Dyn. World 2016 non-growing season crops	2	1
NLCD 2016 cultivated crops	0	0
NLCD 2016 pasture/hay	6	2
Dyn. World 2016 growing season trees	38	54
Dyn. World 2016 non-growing season trees	26	42
NLCD 2016 deciduous forest	19	27
NLCD 2016 evergreen forest	0	0
NLCD 2016 mixed forest	1	8

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