Identifying Forest Conversion Hotspots in the Commonwealth of Virginia Using Multitemporal Landsat Data and Known Change Indicators

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ABSTRACT

This study examines the effectiveness of using the Normalized Difference Vegetation Index (NDVI) derived from 1326 different Landsat Thematic Mapper and Enhanced Thematic Mapper images in finding isolated housing starts within the Commonwealth of Virginia's forests. Individual NDVI images were stacked by year for the years 1995-2011 and the yearly maximum for each pixel was extracted, resulting in a 17-year image stack of all yearly maxima (a 98.7% data reduction). Using location data from housing starts and well permits, known previously forested housing starts were isolated from all other forest disturbance types. Samples from housing starts and other forest disturbances, as well as from undisturbed forest, were used to derive vegetation index thresholds enabling separation of disturbed from undisturbed forest. Disturbances, once identified, were separated accurately (overall accuracy = 85.4 percent, F-statistic = 0.86) into housing starts and other forest disturbances using a classification tree and only two variables from the Disturbance Detection and Diagnostics (D^3) algorithm: the maximum NDVI in the available recovery period and the slope between the NDVI value at the time of the disturbance and the maximum NDVI in the available recovery period. Landsat time series stacks thus show promise for identifying even the small changes associated with exurban development.

GENERAL AUDIENCE ABSTRACT

The objective of this study was to determine whether low-density development in previously forested areas can be identified using a time series of maximum annual vegetation greenness derived from the Landsat earth observing satellite missions. The study area was the Commonwealth of Virginia, USA. This study used 1326 different Landsat satellite images from the years 1995 through 2011. Each image contained over 34 million pixels, which were converted to a value between 0 and 1 that indicated how vegetated they were (a higher value being more vegetated). When houses are constructed trees are removed, thus lowering (at least temporarily) the overall greenness in a given area. Using location data from housing starts and well permits, known previously forested housing starts were isolated from all other forest disturbance types. Samples from housing starts and other forest disturbances, as well as from undisturbed forest, were used to develop greenness thresholds enabling separation of disturbed from undisturbed forest. Disturbances, once identified, were separated accurately (overall accuracy = 85.4 percent) into housing starts and other (non-housing) disturbances using a classification tree and the highest greenness a pixel attained in the available years after being disturbed (indicating how much vegetation returned in the recovery period) as well as the slope from the year of the identified disturbance to the year that had the highest value in the available recovery period.

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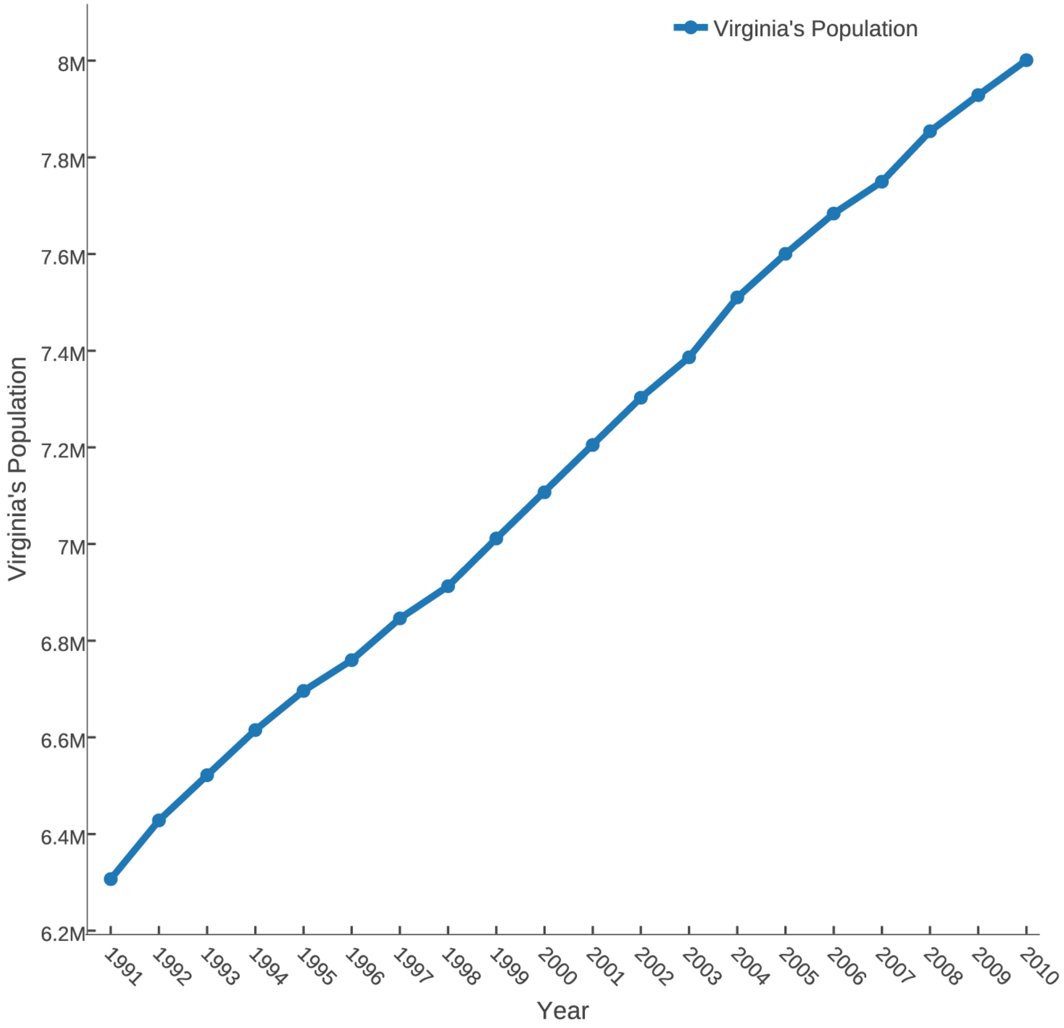
1. Introduction

1.1. Background on Forest Loss

The forested landscape in the Commonwealth of Virginia is in the process of being dramatically changed due to an increase in exurban development. Based on US Census data, Washington DC has 11 counties with at least one-fifth of their residents living in exurban areas [1]. Berube et al. defined exurban areas as communities located on the urban fringe that have at least 20 percent of their workers commuting to jobs in an urbanized area, exhibit low housing density, and have relatively high population growth [1]. Since 1990 population and migration gains in non-metropolitan counties have continued to increase [2, 3]. Based on US census data, Virginia has seen a population increase of 21.2% from 6,187,258 in 1990 to 8,001,024 in 2010 as seen in Figure 1 [4, 5].

Figure 1. Population growth in the Commonwealth of Virginia from US Census Data showing a 21.2% increase in population over a 20-year period.



According to the ninth forest inventory of Virginia, 15.9 million acres (62 percent) of Virginia's land area was forested as of 2011 [6]. Other than development the Commonwealth has experienced other forms of forest loss such as forest harvests and conversion to agriculture.

Nationally the United States saw a population increase of 13.2% between the 1990 and 2000 census, while exurban areas grew by 31% over that same time frame [1, 5]. As of 2000 the typical exurban census tract had 14 acres of land per home, compared to 0.8 acres per home in the typical tract nationwide [1]. Due to the increase in exurban landowners, large single owner acreages are being parceled into these smaller less manageable tracts.

The forested landscape is changing from large contiguous forests to forests that are intermixed with development. The general definition of a forest, according to Helms [7] (p. 70), is "an ecosystem characterized by a more or less dense and extensive tree cover…" This definition does not encapsulate the evolving nature of forests that are being disrupted by human factors. The Federal Register defines wildland urban interface (WUI) as; "…where humans and their development meet or intermix with wildland fuel [8]. This definition was developed specifically to identify the increasing fire risk for homes in the forested landscape as the number of these homes grew [8-10]. However, it does not fully encapsulate other concerns associated with exurban development in forested areas such as water quality, zoonoses, habitat fragmentation, biodiversity loss, exotic species introductions, and the like [11,12].

The importance of accurate information describing the nature and extent of land cover changes over time is increasing, especially for forested areas. Loss of forest to development is an important issue globally, as well as in the Commonwealth of Virginia. The Commonwealth's forests are economically and ecologically important, and identifying conversion hotspots will enable policy makers to help stem the tide of forest loss. Areas that are experiencing forest loss due to exurban development as well as other disturbances are currently difficult to identify and quantify using an accurate and cost effective method.

1.2. Remote Sensing

Satellite- and sampling- based approaches have been used to identify land cover and its changes over time. An acknowledged limitation of these satellite- and sampling- based approaches to estimating land-cover change is that it cannot detect some significant land-use and land-management trends [13]. Currently the Multi-Resolution Land Characteristics Consortium (MRLC) produces National Land Cover Database (NLCD) products on a five year cycle, twice as frequent as the original temporal cycle (10 yrs.) [14, 15]. A five year gap is a long span, temporally, to show trends at regional and local levels. In addition, according to Kennedy [16], change analyses based on two-date change detection methods do not fully tap the interrelationships among many multitemporal images. Since NLCD products are at the national scale, there are constraints to improving its temporal frequency, including timely acquisition of imagery, financial costs, and analytical methodology development [15]. Given the difficulties in improving the temporal cycle, other approaches for specific user applications need consideration.

No remote sensing change detection method has solely focused on detecting exurban development in forested areas, though census-based methods have been used [12]. Typically stakeholders who are trying to identify forest disturbances are concerned with all causes of disturbance, precluding a single focus investigation. Investigations focusing solely on exurban development using spectral change detection have not been conducted. Exurban development in the forested landscape has different consequences than exurban development in the non-forested landscape [12].

Remote sensing, in general, provides a vast source of data that allows us to analyze the landscape on an immense scale. Changes to the landscape are difficult to detect without remote sensing. Scientists have utilized remote sensing products to monitor changes in types of land cover over time, in addition to monitoring soil moisture, ocean temperatures, glacier size, and the spread of wildfires. Scientists are currently discovering new ways to harness the richness of data in remote sensing. As one of the most important sources of remote sensing data, the Landsat program has provided continuous data since 1972 [17].

The Landsat 5 Thematic Mapper (TM) and Landsat 7 Enhanced Thematic Mapper Plus (ETM+) sensors provide moderate resolution (30 m) imagery and have, over the life of the Landsat program, aided scientists in agriculture, forestry, environmental science, earth science, and social science [17]. Landsat is an excellent tool for tracking change, based on the quality and quantity of data. Each path/row image acquired by an individual Landsat satellite is repeated every 16 days, potentially (without cloud cover, etc.) providing 22 images per year. The number of potential images available in a given path/row per year is why this sensor is suitable for detecting forest loss. By taking advantage of all scenes available, scientists can leverage the resulting temporal richness to detect subtle changes in the landscape that cannot be detected by using only one or two scenes per year.

Anthropogenic forest disturbance (especially in the actively managed forests of the U.S. Southeast) often occurs in the form of forest thinning or harvesting activities and does not necessarily result in land use change. However, some forest disturbance is the precursor to land use change (typically, to agriculture or developed classes). Once a forest disturbance is detected, examination of the post-disturbance period enables separation of land use change from changes related to forest management. The type of land use change can also be detected using data from the post-disturbance (recovery) period [18].

1.3. Differences in Data Acquisition and Use

NLCD is a national Landsat-based product that supports a wide variety of federal, state, local, and nongovernmental applications [14]. Within each path / row three minimally cloud-impacted dates are selected within (if feasible) one year. The chosen dates are designed to capture seasonal variability with one of each three-scene group selected at or near the peak greenness (maximum NDVI) [16, 19]. The opportunity to accurately capture all pixels at their peak greenness within any given path / row / year is limited by only using three dates, the need for limited cloud occlusion on a scene-specific basis, and processing on a per scene / mapping unit (rather than per pixel) basis. Additionally, as noted earlier, by focusing on one year every five years, NLCD is limited in detecting subtle changes that occur between acquisition dates.

With the same approach, NLCD impervious surface products are used to detect changes in impervious cover and an urban mask is used to mask out non-impervious surface area to obtain a final impervious change map [20]. NLCD impervious is not suited for detecting exurban disturbances because it uses a nonurban mask to remove the land cover types that are not classified as urban [20, 21]. NLCD impervious also identifies clouds as unchanged areas which is not acceptable when identifying exurban residential development [20].

LandTrendr [16] uses dense Landsat time series stacks and a trajectory-based approach. It uses multiple images per year primarily acquired from mid-July to late August. The LandTrendr employs three strategies: track change in cover condition that persists between years, use a pixel-based structure using the single best values for each pixel for each year, and allow for smoothing of spectral noise in long-duration signals while also enabling the capture of abrupt events [16]. Unfortunately, LandTrendr has some limitations that contrain its potential utility for detection of exurban housing starts, as follows: remnant clouds can be construed as land cover change, the vegetation index value for a given year/pixel is not necessarily from the maximum leaf area condition, and noise removal can remove especially subtle changes.

Vegetation Change Tracker (VCT) also uses Landsat time series stacks, however their temporal intervals are varied due to clouds and image availability. “The VCT is on the spectral-temporal characteristics of land cover and forest change processes, employing two major steps; first each image in the time series is preprocessed to indicate forest likelihood, then the derived indices and masks are analyzed to map disturbance" [22]. In the event that clouds persist in an image for VCT they are mapped as forest disturbance. The number of scenes in each Landsat time series stack year is low and creates the potential of not capturing the best pixel for all pixels in a year. VCT is able to detect most stand-clearing disturbances (including larger urban development), but it has not been shown to be able to consistently detect small-extent ($<30m^2$) exurban residential development [21, 22].

Change detection (CD) using exponentially weighted moving average (EWMA) charts is a method that can incorporate new data as they become available and grants users the ability to continually monitor change [23]. EWMA charts are adept at detecting small gradual changes. They use, for any given time in the time series, the history of the data for a given pixel to determine at the specified time whether it is a false signal. By being able to filter out false signals, EWMA charts can accurately determine space, severity, and time of disturbance [23]. EWMA-CD has strong potential for detecting exurban development, but is data and computationally very intensive. This method is likely suitable for detecting exurban development in forests, but data volume and computational intensity likely preclude use by many target stakeholders (forest managers, planners, agencies, etc.).

Sen et al. [18] assembled an interannual Landsat chronosequence using the most cloud-free scene in a given year’s growing season. Surface mining disturbances could be separated from other disturbances by analyzing the post-disturbance recovery, but accuracy was circumscribed by remnant clouds and subtle phenological differences. Coal mines are large areas of disturbance, and Sen concluded that an object-based approach was more robust than a pixel-based approach [18]. Using an object-based approach to detect exurban residential development using moderate resolution earth resource satellite data has the potential to enable detection of land clearing development such as subdivisions. However, pixels are better suited for identification of smaller disturbances.

With respect to the techniques referenced above, each is constrained with respect to finding isolated housing starts forest covered areas. NLCD products are too infrequent to detect these subtle changes. VCT, and LandTrendr, and Sen's efforts are plagued by phenological difficulties (i.e., do not ensure the maximum leaf area condition), since each typically use a single date per year. LandTrendr smooths out noise to keep false disturbances from being captured, potentially eliminating subtle disturbances like exurban residential development. VCT and Sen's efforts are susceptible to cloud contamination. EWMA-CD may be too computationally and data intensive for many operational users at this juncture.

1.4. Background and Importance of Disturbance Identification

A study by Sen [18], assessing whether coal mines in a forested ecosystem can be separated from other forest replacing disturbances, was the genesis of our study. Sen et al. [18] compared objects to pixels using NDVI, the tasseled cap greenness-brightness ratio, and Landsat TM band 3. An image from each year from 1984 to 2008 (excluding 1992 and 1996) enabled creation of a trajectory with which to classify disturbances. They hypothesized that the immediate revegetation of reclaimed mines could be used to distinguish those sites from other landscape disturbances [18]. To accomplish this for an entire Landsat scene, they developed a program to automate the derivation of three diagnostic spectral trajectory variables (disturbance minimum, recovery maximum, and recovery slope) and the year of disturbance for both pixels and objects [18]. Objects enabled more accurate identification of mine disturbances, in part because of the greater variance in pixel-based recovery trajectories [18]. The study also showed that NDVI was the best of the three indices when pixels were used as the analysis unit [18].

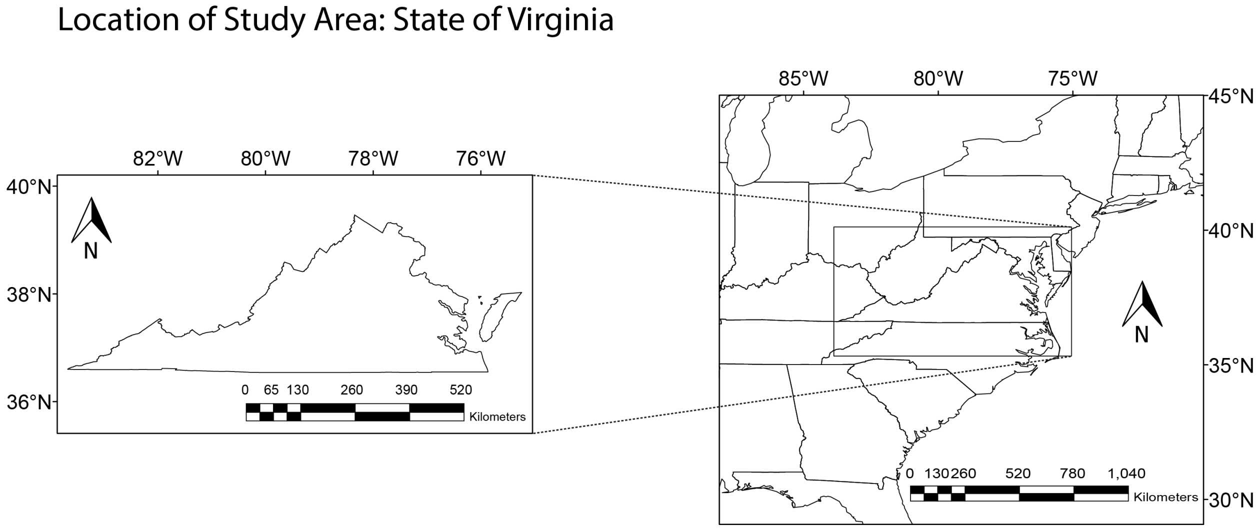
The objective of this study was to develop a straightforward and easily implemented method by which forest loss due to low-density residential development can be mapped accurately using multi-temporal Landsat data. We leveraged other indicators of exurban development, such as well permits and known housing starts, to develop and ensure the quality of our training data. Using the resulting technique, we developed a map of forest conversion hotspots, (by 6th-order hydrological unit and by county) in the Commonwealth of Virginia.

2. Materials and Methods

2.1. Study Area

The study area is inclusive of all counties and municipalities within the Commonwealth of Virginia as shown in Figure 2.

Figure 2. Study area, the Commonwealth of Virginia, USA.



2.2. Landsat Data

Landsat-5 TM was the predominant source of our data. Landsat-7 ETM+, was not used for scenes after May 31, 2003 due to the scan line corrector (SLC) failure. Images used were from the WRS-2 path / rows as shown in Figure 3. All available reasonably cloud-free L1T scenes from the above two Landsat sensors were acquired for the dates 1995-2011 over the Commonwealth of Virginia. These scenes were predominantly from the peak growing season, however if there were too few reasonably cloud-free scenes we selected scenes just outside of the peak growing season. The year 1995 was chosen as the study start date, as it was the earliest year we could accurately verify our validation data set using Google Earth. The surface reflectance products from the Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS v. 1.0.0) were used [25].

2.3. Initial Satellite Data Processing

The analysis for the Commonwealth of Virginia consisted of 1326 unique scenes (Appendix A). Each acquired image was subjected to sequential processes that included converting to NDVI, removing irrelevant values (NDVI values < 0 and > 1 recoded as NODATA), stacking the individual NDVI images by year within a specific path/row, and extracting the maximum value per pixel per year. Figure 4 illustrates the procedures used to develop a 17 year time series stack of the yearly maximum NDVI values.

For the initial scene 16/34 we processed 193 unique scenes between 1995 and 2011 to determine the requirements for the remainder of the study area. Scene 16/34 was chosen as the initial scene because it was representative of the differing terrains within the Commonwealth. The normalized difference vegetation index (NDVI) [26] was computed for each image and the images were stacked by year. Each yearly stack was processed to extract the maximum NDVI value for all pixels. This resulted in 17 one layer images which were combined into one 17 layer image.

Figure 3. Number of scenes by year for each of the path/rows listed in the legend included in study.

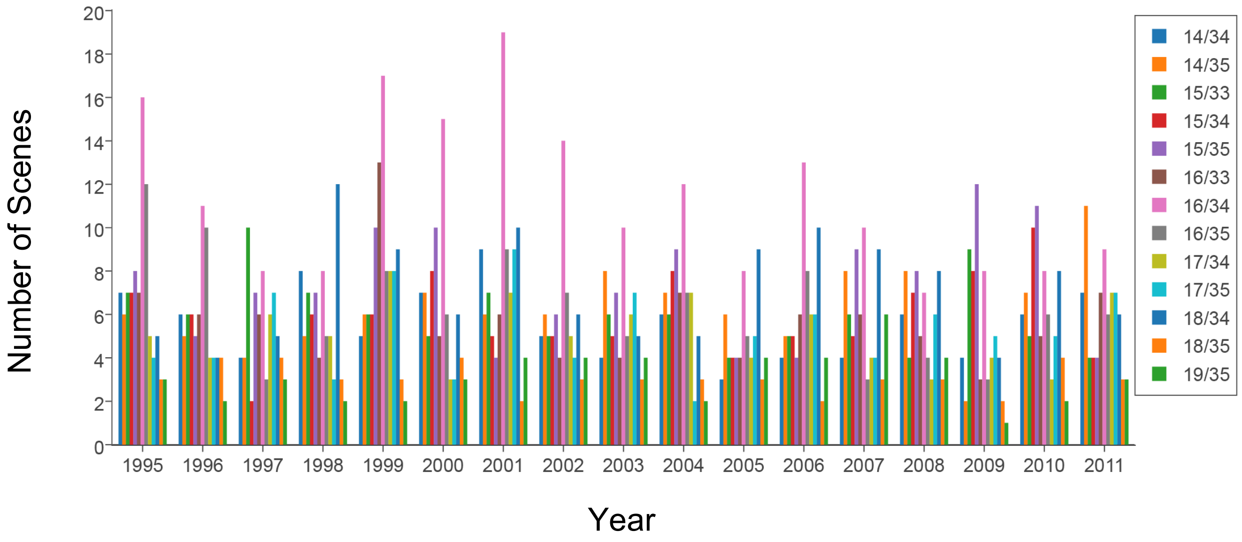
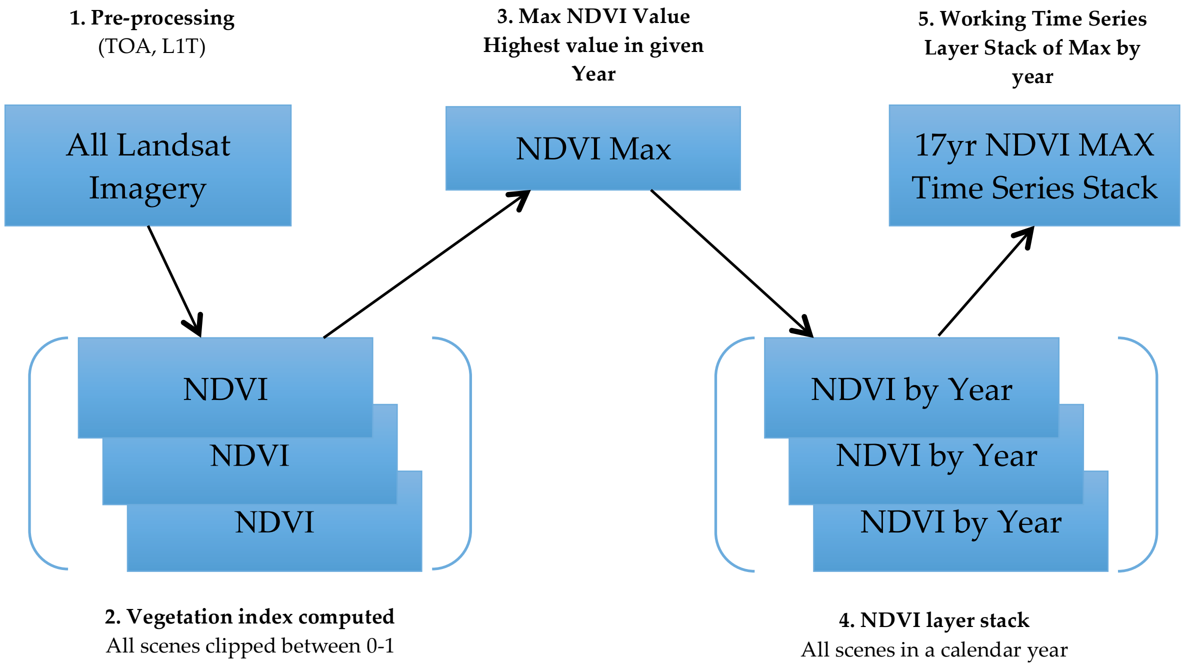


Figure 4. Principal procedures used for preprocessing and development of time series.



2.4. Classification Scheme

Our goal was to distinguish residential disturbances from all other disturbances on a single pixel scale and to date each disturbance. *House Forested* was defined as a disturbance that resulted in a permanent change to the forest land cover. *Disturbed* was broadly defined as any other disturbance to the forest land cover that was not a permanent change. This classification was applied to pixels by identifying each type of disturbance and then classifying them as either *House Forested* or *Disturbed*.

Building a house in the forest landscape requires the clearing of vegetation for both the building and septic system. Every new home not connected to a municipal sewer system must have an onsite sewage disposal system. Virginia Code, 12 VAC 5-610-10 states, "the minimum absorption area for single family residential dwellings shall be 400 square feet" (~37.2 m) [27] (p. 96). The absorption area is typically at the bottom of excavated trenches. With the absorption area of the trenches limited to 18-36" (45.7-91.4 cm) width and a minimum lateral separation of 3 times the width of the trench, the cleared area required can cross multiple Landsat pixels [25]. In addition to the size of the drain field, the disturbed area may increase depending on other setback requirements such as distance to wells, dwellings and trees. Virginia Code, 12 VAC 5-610-10 requires, "removal of vegetation. Vegetation such as maple, cottonwood, willows and other plant species with extremely hydrophilic (water loving) root systems shall be removed for a minimum of 10 feet (304 cm) from the actual absorption areas. Other trees should be removed from the absorption area" [27] (p. 72).

Within the building footprint and drain field, this clearing of vegetation is relatively permanent (i.e., no trees will be replanted in the footprint of the home or the drain field). Homeowners commonly plant grass or ground cover over the other cleared areas and, as such, the NDVI value of the disturbed area will not indefinitely remain low.

2.5. Developing Training and Validation Datasets

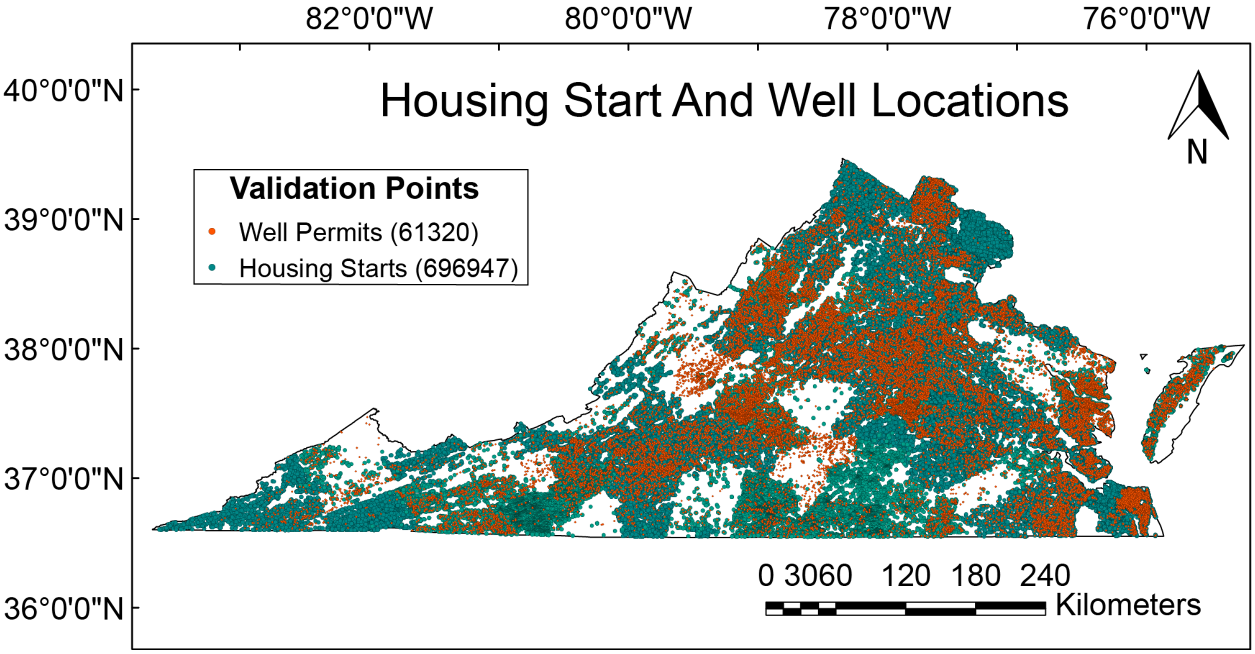
Development of a training dataset required two sources of spatially-specific ancillary data. The first dataset was comprised of all well permits issued for the Commonwealth of Virginia. Permit records were obtained through the Virginia Department of Health for the years 2000-2013, acquired on March 12, 2013. The second dataset is from commercial sources DataQuick and Core Logic. This second dataset is a list of all housing starts within the Commonwealth of Virginia from 1990 to present as of the acquisition dates; November 4, 2014 and June 4, 2015.

Exurban developments do not typically have access to a public water source. These new homes require access to water. Every new private well has to be approved through the Virginia Department of Health and all permit records are kept by the Commonwealth. This is accomplished through the Private Well Regulations; Title 32.1 of the Code of Virginia, and specifically 32.1-12 and 32.1-176.4, provide that the State Board of Health… "is empowered to supervise and regulate the construction and location of private wells within the Commonwealth" [28] (p. 6). The dataset includes the site address as well as application type and purpose. The addresses in this data set were geocoded using ArcMap 10.1. The resulting XY points were sorted by % match and any that were less than a 100% match were discarded.

The wells dataset is valuable in and of itself for locating exurban development. However, most geocoded points are along roads, and the actual disturbances are usually located well off the road. The wells dataset also cannot identify the magnitude of disturbance. In addition, some rural developments may share a community well, which prohibits identification of all homes within that development by merely using well permits.

Our second dataset supplements the former by identifying all residential housing starts within the Commonwealth of Virginia. It provides the date of initial construction and the site address in addition to other information. Every new residence is required to have a construction permit from the county in which it resides. No state entity exists that collates or tracks these permits, and not all counties keep electronic records that are easily accessible. DataQuick and Core Logic provided the data in its collated form for all counties from using the available data. This resulted in over 5 million records delivered in ASCII form. Unfortunately, some counties in the commonwealth lacked any housing start information, as seen in Figure 5. However, access to housing start data enabled identification of new houses even when the new construction did not require a well permit (i.e., city water or community well).

Figure 5. Display of all geocoded points for both datasets from which the validation dataset was sampled.



There were 696,947 housing starts, and 61,320 well permits, that were within the temporal range. The difference in volume between the datasets is due to the fact that housing starts include those which are connected to municipal water sources. Well permits are limited in volume because at the time of the permit being granted many of the build sites did not have an address that could be geocoded. Approximately half of the well permits were excluded because of this. Therefore, these datasets could not exclusively track all exurban developments. The cost of a commercial data source on housing starts is also prohibitive, especially when it lacks coverage for the entire Commonwealth. It does, however provide an excellent source of sample points.

NLCD's 1992 forest cover (legend numbers: 41 Deciduous Forest, 42 Evergreen Forest, and 43 Mixed Forest) was used as the starting point for known forest [29] (p. 651). Using ArcMap 10.1 we clipped forest from NLCD and then clipped it to the shape of Virginia.

A total of 1800 random sample points (Appendix C) were selected for training and validation using the well and housing start data. The process of acquiring and validating these points required well over 100 man hours of painstakingly validating each XY location using Google Earth historical imagery, which for our purposes, had usable imagery dating back to 1994-1995. Any point that could not be accurately validated due to lack of clear imagery was discarded, this resulted in a dataset that contained 1531 user verified unique sample points. Each point, if not directly over a disturbance, was moved to the disturbance, as some of the geocoded addresses were located over a road and not the pertinent disturbance.

290 of the 1531 verified sample points were confirmed as a home built. The remaining 1241 points were within the 1992 NLCD forest layer. Of those points, 848 were useable as *Forest* (used as baseline for persisting forest over the time series) and 176 were useable as *Disturbed* (omitted points fell in categories like water and agriculture despite their NLCD classification as forest). The resulting data set had 1314 samples (290 *House Forested*, 848 (Persistent) *Forest*, and 176 (other) *Disturbed*. These sample points were intersected with the mosaic stack of NDVI maxima per year so that each sample had a category and associated 17-year (1995-2011) time series.

2.6. Threshold Identification

Using the 848 *Forest* sample points (and the mosaic stack of NDVI maxima per year from 1995 to 2011) we heuristically identified an NDVI value of 0.77 as the *Vegetation Threshold* for forest cover (i.e., pixels with an NDVI value at or above 0.77 for at least three years (the *Minimum # of Years at Vegetation Threshold*) were considered to have been forest at some point in the study period). We are confident in our threshold selection because we verified, using historical photography on Google Earth Pro (©2013 Google Inc.), that nearly all our known samples with an NDVI value of 0.77 were forest, but we are aware that there are forest pixels in the study area that may have been below this threshold but still forest. In a similar fashion, the disturbed (*House Forested* + *Disturbed*) sample points were used to set the *Disturbance Threshold* at 0.76 (in other words a pixel whose lowest NDVI value was below 0.76 was considered to be potentially disturbed). However, if the NDVI value in the year following a potential disturbance is above the *Next Year Threshold* (0.81, also heuristically determined) the tentative disturbance flag is removed and the pixel is not considered to be disturbed at the initially flagged time. Most disturbances, of course, had NDVI values far below 0.76, but some exurban housing starts in previously forested areas are very subtle. As such, our *Disturbance Threshold* is necessarily higher than values commonly used for stand replacing disturbances.

2.7 Handling Cloud Contamination

Cloud contamination was handled in the following ways:

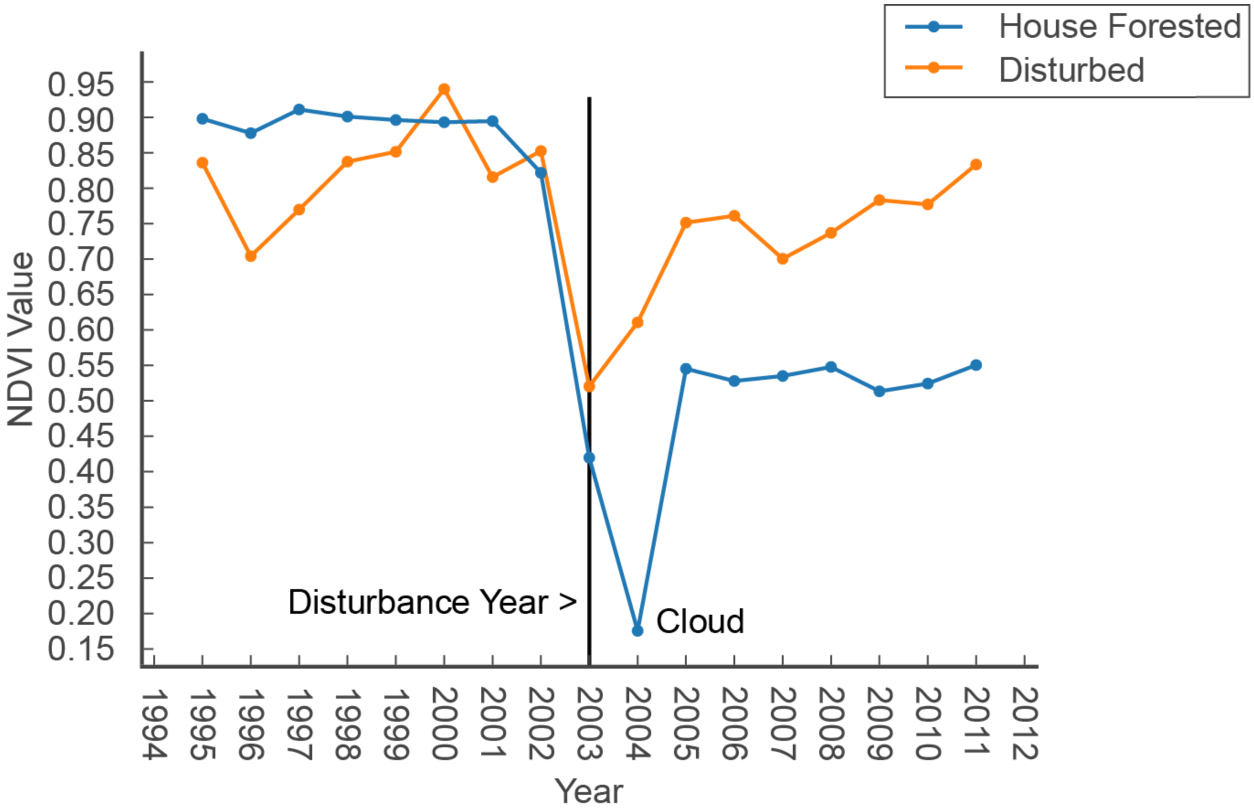
1. *Scene selection was designed to minimize cloud presence.* All images with 10% cloud cover or less were acquired for a given path/row/year. If there were fewer than three images with less than 10% cloud cover in each growing season, we selected additional images up to 40% cloud cover if those images initially appeared to have cloud free pixels where our other images were obscured.
2. *The minimum NDVI value from 1995-2011 could not be below the* Cloud Threshold *of 0.4 and still be considered disturbed*. If it was, the next smallest value in the time series was checked to see whether it was below the *Disturbance Threshold* but above the *Cloud Threshold*, and so on, up to the *Number of Low Values Searched* (3). This presupposes, of course, that a pixel is not obscured by clouds more than four years in the time series, which was borne out in practice given the stringent scene selection guidelines.

2.8. Interclass Differences in Disturbance and Recovery Dynamics

Most disturbances other than *House Forested* are forest harvests, and the *Disturbed* areas are either replanted for future harvests or are left to naturally revegetate. Preliminary analysis of initial NDVI trajectories, coupled with findings from previous studies [18], indicated that difference in revegetation trajectories would likely allow separation of the disturbance classes. At the onset of the disturbance, both classes' NDVI values drop dramatically as shown in Figure 6. However, as also shown in Figure 6, the *House Forested* class recovers to a lower Recovery Maximum (High) NDVI value.

We tested the same three variables (*Disturbance Minimum*, *Recovery Slope*, and *Recovery Maximum*) as Sen et al [22], in addition to three new variables (*Average of First Three Recovery Years*, *Slope over First Three Recovery Years*, and *Average of Three Lowest NDVI Values*). The three new variables were derived from careful examination of differences pre- and post-disturbance that appeared to enable separation of housing starts from other forest disturbances.

Figure 6. Classes *House Forested* and *Disturbed* over time. Both were flagged as the low in 2003. *House Forested* remains lower than *Disturbed* through the remainder of the time series and is much more constant.



2.9. Automated Disturbance Detection and Diagnostics

The Virginia Tech Disturbance Detection and Diagnostics (D^3) Program (Figures 7 and 8) is written in Fortran 95. The code for the program is in Appendix B. The program was originally developed to identify mining disturbances and recovery trajectories [18]. For our investigation, we expanded on the concept and added variables that were better suited to detect small disturbances on a pixel by pixel basis.

Table 1. User-Specified Parameters

*D*³ Input Prompts	Definition and Use
Vegetation Threshold	Pixels above this value are labeled forest/vegetation
Minimum # of Years at Vegetation Threshold	A pixel must exceed the vegetation threshold a minimum of 3 yrs
Disturbance Threshold	A pixel is considered disturbed for a year if its value falls below this threshold
Next Year Threshold	The pixel value for the year immediately following the identified low is used to separate false lows from a true disturbance. If the value is above the threshold the identified low is discarded and the next lowest value is considered.
Cloud Threshold	The identified low value cannot be below this threshold. Values below this predominantly indicate (and are assumed to be) clouds.
Minimum # of Years Since Disturbance	This is the number of years over which the static average and slope are computed
Number of Low Values Searched	This is the number of times *D*³ searches for a low value in a pixel time series vector.

The mosaic stack of NDVI maxima per year (if it was forest in the 1992 NLCD) was the input to D^3. Program flow is detailed in Figure 8, though we include a simplified overview of the process here. Required input parameters and their values are shown in Figure 7 and Table 1. As noted in Section 2.6, to double-check that each pixel was (at least initially) forest, we ensure that the pixel exceeds the *Minimum # Years at Vegetation Threshold* (0.77) for at least three years (the *Minimum # of Years at Vegetation Threshold*), otherwise that pixel is omitted from further analysis. To further reiterate, a pixel is (initially) considered to be disturbed if the lowest NDVI value in the time series falls below the *Disturbance Threshold* (0.76). To ensure false lows are not identified as disturbances, the NDVI value in the year following the flagged disturbance has to be below the *Next Year Threshold* (0.81). Low NDVI values due to clouds (which could be mistaken as disturbances) are removed if the NDVI value is below the *Cloud Threshold* (0.4).

Diagnostics (Figure 8 and Table 2) are computed only on pixels flagged as disturbed. The only input parameter (Table 2) used in the computation of the output diagnostics is the *Minimum Number of Years* (3) *Since Disturbance* used to compute the *Average of First # of Recovery Years* and *Slope over First # Recovery Years*.

Figure 7. D^3 Program flow chart identifying program prompts and user supplied responses as an overview of the process.

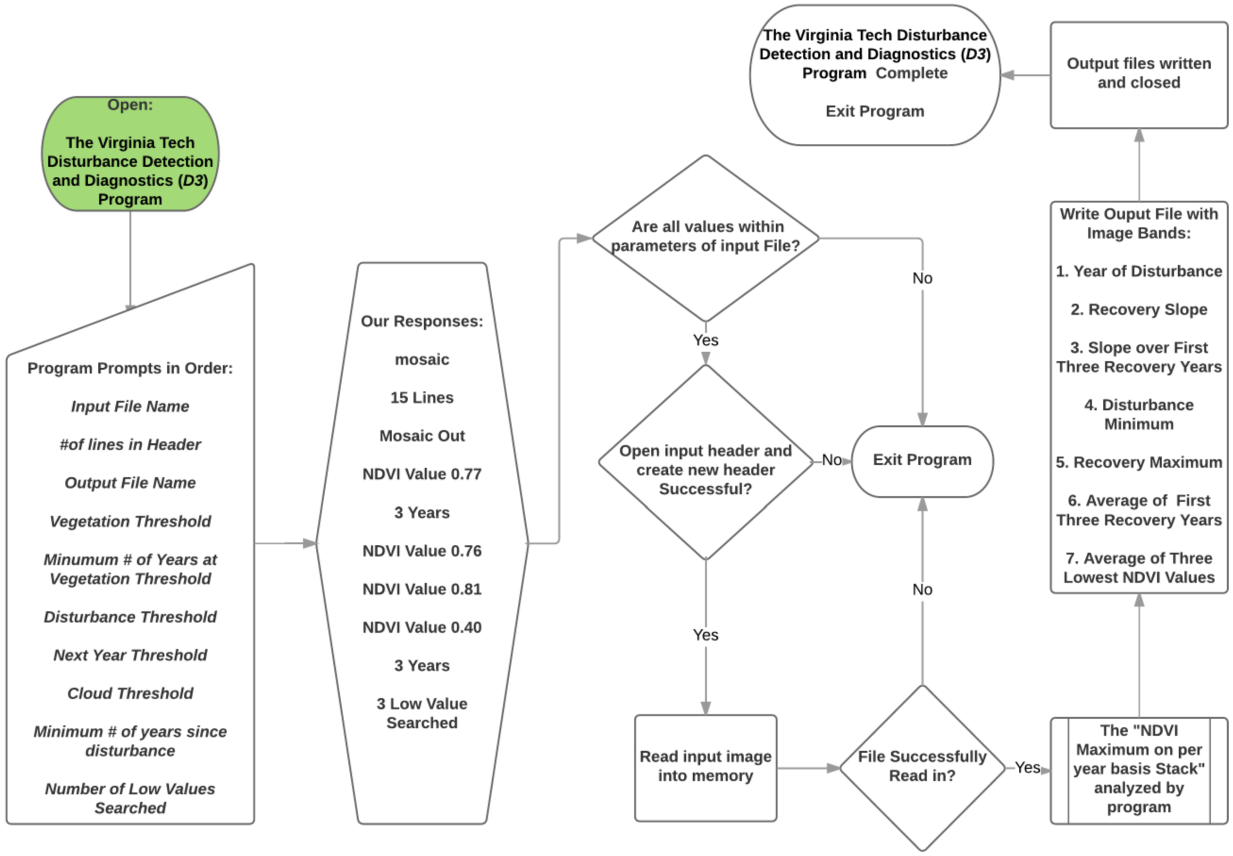
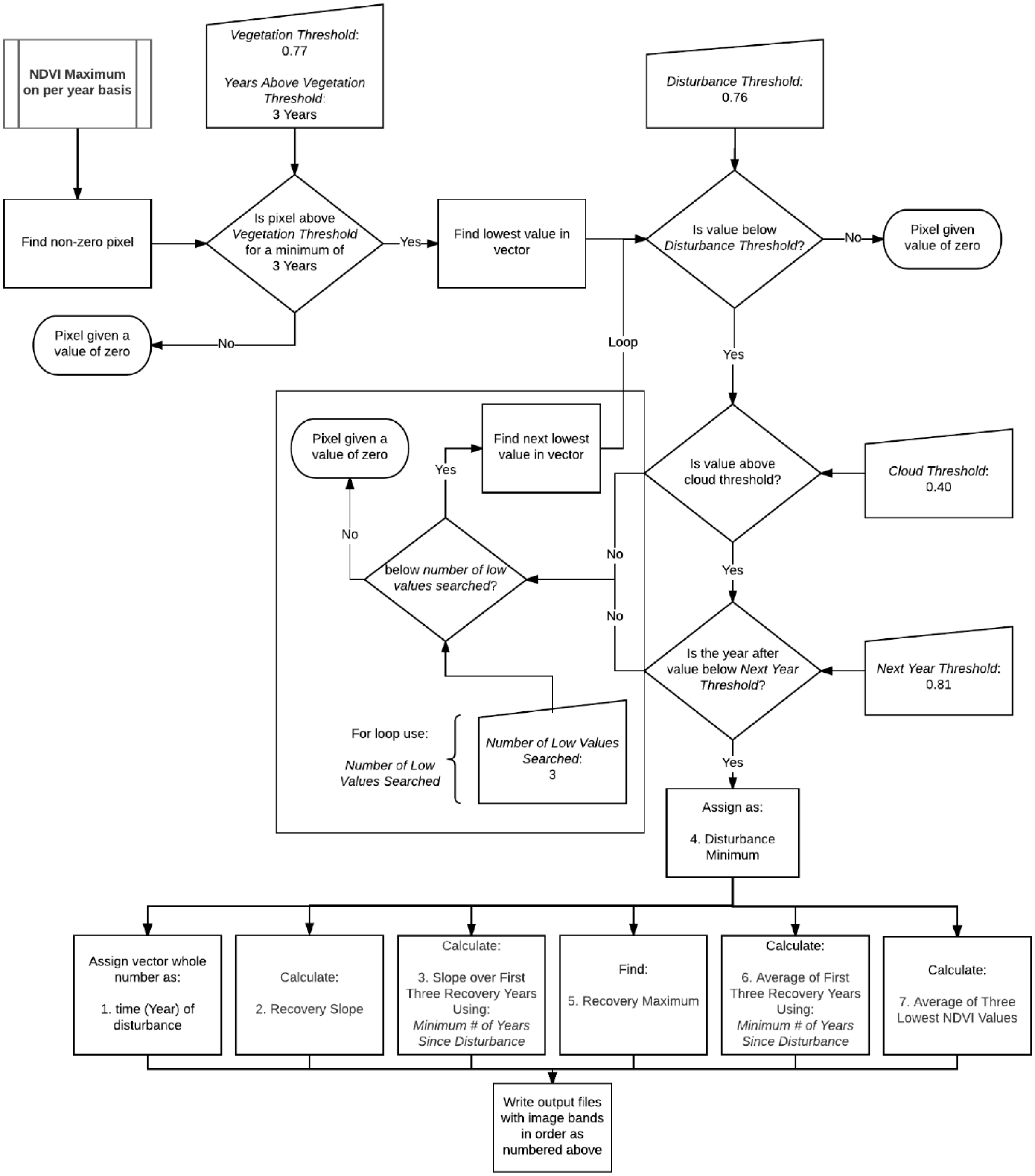


Figure 8. Flow chart of calculations within program illustrating how it identifies a given pixel as disturbed or undisturbed, and, if disturbed, what derived indices were calculated.



The output image is comprised of seven layers as labeled in Table 2.

Table 2. D^3 Output's 7 layers

Output layers of D^3

1. Year of Disturbance
2. Slope Low to High
3. Slope over First *x* Post Disturbance Years
4. Low (value when first fell below threshold)
5. Recovery Maximum (Highest NDVI Value after Low)
6. Average (of *x* Post Disturbance Years)
7. Average of Lowest Three Values in Entire Time series

2.10. Developing a Model to Separate House Forested *from* Disturbed

A subset of the original training and validation sample in *House Forested* and *Disturbed* classes was created to examine homogeneous pixels (as assessed using historical orthophotography on Google Earth) flagged as disturbed by D^3 and excluding disturbances that occurred in the final three years of the time series (to ensure calculation of *Slope over First x Post Disturbance Years* and *Average of x Post Disturbance Years*). This subset contained 166 *Disturbed* samples and 197 *House Forested* samples. A CART® model to separate *House Forested* from *Disturbed* classes was developed using Salford Predictive Modeler v6.6. Outputs 2-7 shown in Table 2 were used as the predictor variables and the class (*House Forested* or *Disturbed*) as the target. All program defaults were used apart from doing a 150-fold cross-validation (from which the test sample accuracy statistics were calculated).

2.11 Mapping

The predictor variable thresholds from the CART®-defined best tree were written into Erdas Imagine (2014) Model Maker and applied to the D^3 output image to create the final disturbance map. Using a county mask, pixels identified as House Forested from the disturbance map, and the 1992 NLCD Forest layer, we calculated the percent forest loss by county for the Commonwealth. Through ArcMap 10.1 we used a graduated scale to display the counties relative to each other in terms of percent forest loss due to development. This same method was also applied to the 6th order (12-digit hydrological unit code) hydrological units in the Commonwealth to develop a finer-scale map of forest conversion rates. Overlaying the two maps (counties and hydrological units) allows us to show what parts of the county are being converted at a higher rate.

We visually compared our results to comparable changes (change to Developed classes 21-24) from the NLCD 2001-2011 Land Cover Change Product, a combination of change between 2001/2006 and 2006/2011 [30]. For this graphic we only display flagged changes in the comparable period. To indicate where forest was in 1992, the NLCD forest layer is shown in green. Our dataset of known housing starts was clipped to Blacksburg, Virginia for the years 2000-2008. The year 2000 was chosen as the start date for known housing starts, because the date is from the building permit and not all construction (disturbance) begins at the permit date.

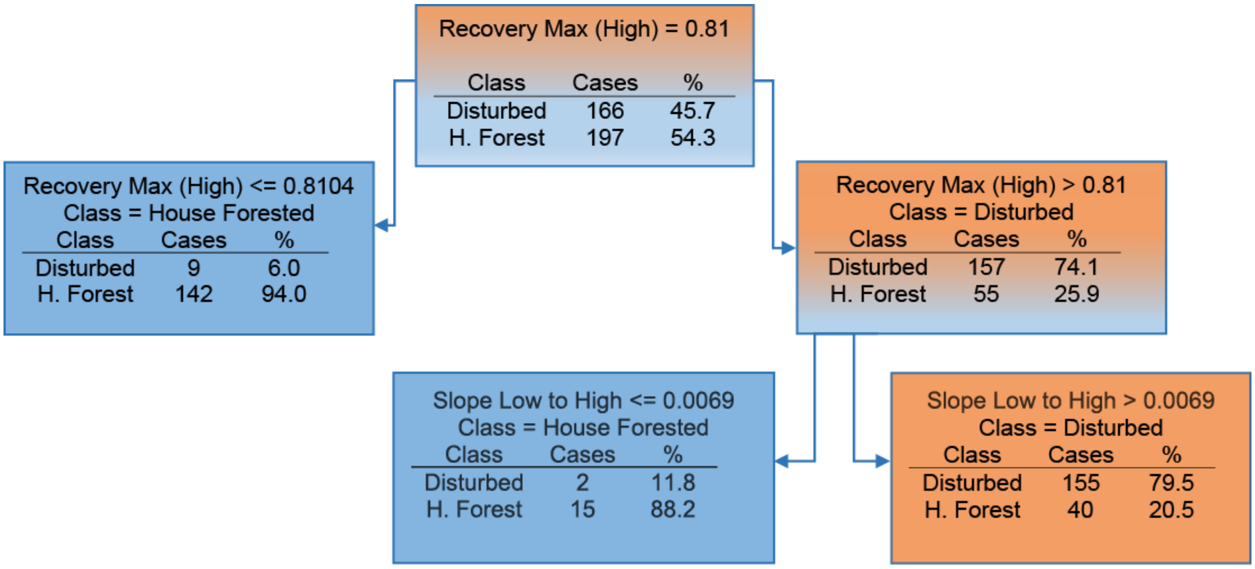
We also produced a map of percent forest impacted by exurban development for our product, D^3, and the NLCD 2001 to 2011 Land Cover from to Change Index (changes from Forest (class numbers: 41-Deciduous, 42-Evergreen, 43-Mixed, & 90-Woody Wetlands) in 2001 to Developed (class numbers: 21- Developed Open Space, 22-Developed Low Intensity, 23-Medium Intensity, and 24-High Intensity) in 2011). Figures for these may be found in the Results section (Figures 12 &13). To derive the percent forest impacted by exurban development, the 1992 NLCD Forest layer (class numbers: 41-Deciduous, 42-Evergreen, 43-Mixed, & 91-Woody Wetlands) was used as the precursor forest cover from with which both the D^3 and NLCD pixels were clipped. The quotient was computed by each individual product pixel count divided by the 1992 NLCD forest layer pixel count within each county and city and then multiplied by 100 to create quantities of percent forest impacted by exurban development.

3. Results

3.1. Training and Validation Data

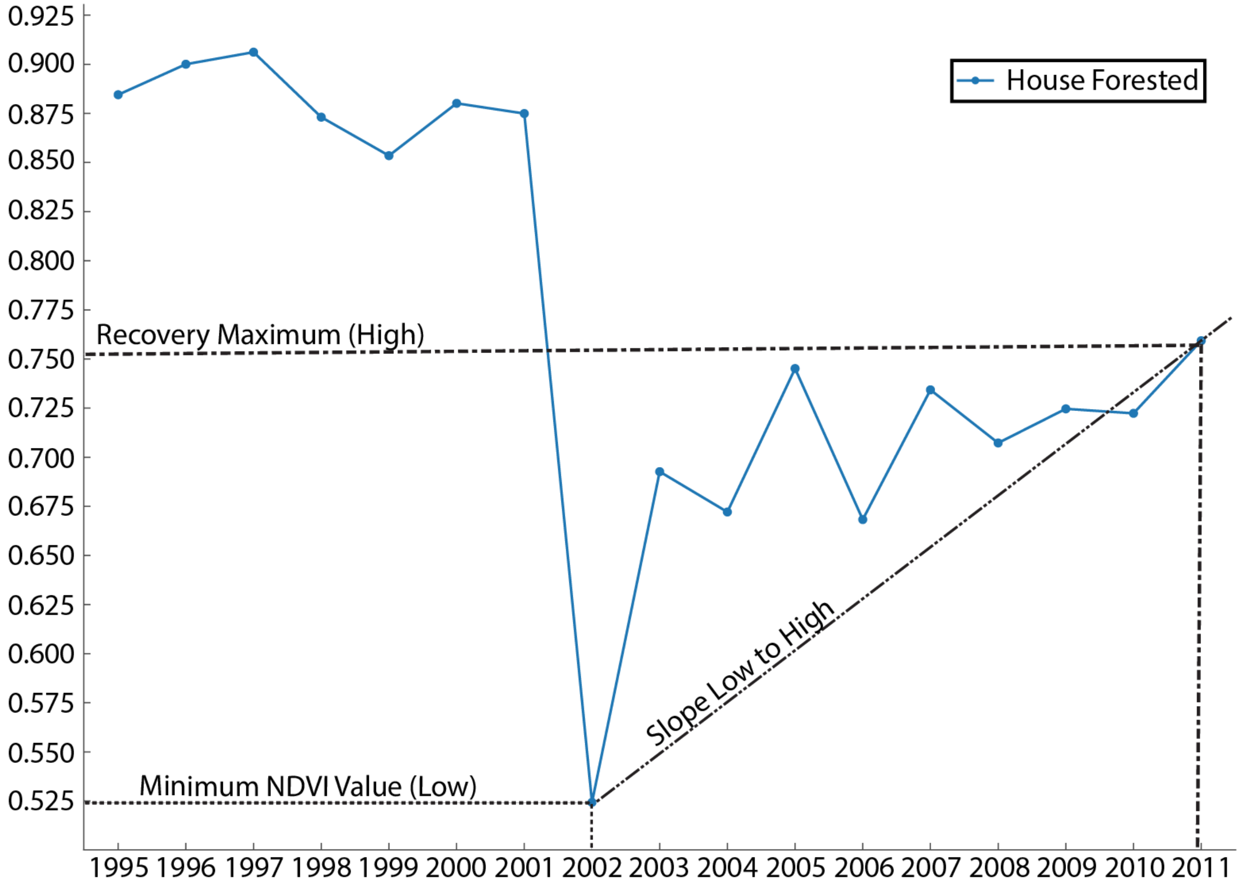
The results from CART® showed that use of two of the five predictor variables enabled the most separation between *House Forested* and *Disturbed,* as shown in Figure 8.

Figure 8. Resulting CART® Tree from Salford Predictive Modeler v6.6. Cases in boxes shaded blue were classified as *House Forested* while cases in the box shaded orange were classified as *Disturbed*.



These two predictor variables were the *Recovery Maximum (High)* NDVI Value and the *Slope Low to High* as shown, for visualization, in Figure 9. The *Recovery Maximum (High)* NDVI Value was consistently higher for *Disturbed* than for *House Forested,* which supports the idea that the *Disturbed* class returns to its pre-disturbed NDVI value since it is not a permanent land cover change. *House Forested* has an average *Recovery Maximum (High)* value of 0.75 compared to *Disturbed*'s 0.87, as seen in Figure 10 (c).

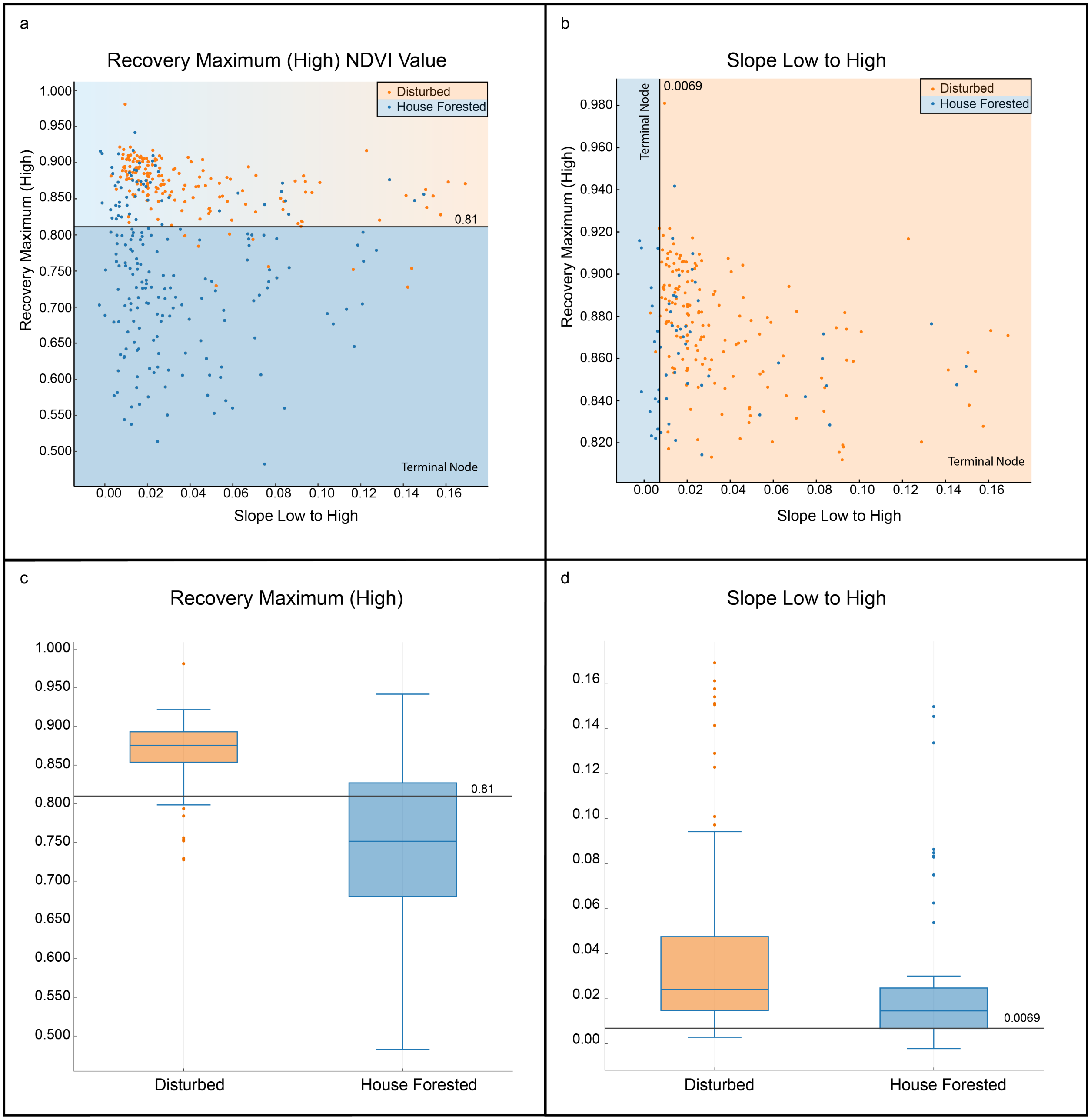
Figure 9. The two selected predictor variables from CART®, where *Recovery Maximum (High)* is the highest post-disturbance value in the time series (regardless of location) and *Slope Low to High* measures the slope of recovery between the disturbance year and the year where *Recovery Maximum (High)* was marked.



The range in the values of the post-disturbance maximum (*High*) of *House Forested* (Figure 10c) was larger than initially expected. This can be attributed both to the size of the disturbance and the location of the disturbance itself. If the initial disturbance was small and in a densely-vegetated area the resulting *High* would naturally be greater. Another reason for the observed large range is that the center of the house and its XY coordinate could be on the edge of a pixel resulting in some, if not most, of its clearing being in a neighboring pixel. If most of the disturbance is in a neighboring pixel, that pixel will be identified as *House Forested* while the validation point will not be. Forty (40) *House Forested* points from our known sample points were misclassified as *Disturbed* due to the split on *High*. These could not be separated using *Slope Low to High*.

The *Slope Low to High* NDVI Value could separate 15 more *House Forested* points from *Disturbed*, with an overall tree improvement of 3.3%. These 15 points had a lower slope than the rest of the 195 sample points, which was expected. We predicted that the *Disturbed* class would recover quicker than *House Forested*. This was predicted because most forest harvests are cyclical and stakeholders have a vested interest in revegetating the harvested area as quickly as possible.

Figure 10. Scatterplot (a) shows the first break in CART® using *Recovery Maximum* (*High*) as the splitter. All blue sample points / terminal nodes are *House Forested*, all orange sample points / terminal nodes are *Disturbed*. The points with *High* < 0.81 are classified as *House Forested* (terminal node); the nonterminal node points above that threshold are displayed in scatterplot (b). Using the splitter *Slope Low to High* results in the final two terminal nodes. Boxplot (c) shows the first split and how most the *Disturbed* class is above the split, with 9 instances falling below the split. Boxplot (d) shows the second split and illustrates the variability of the slopes within the two disturbance types.



3.2. Classification Accuracy

Classification accuracy assessment numbers were extracted from the resulting CART® tree. Information from the prediction success table (test sample) has been reproduced and illustrated in Table 3 below with the addition of the user's and producer's accuracies. The resulting F-statistic for *House Forested* is 0.86.

Table 3. Producer's accuracies (PA) and user's accuracies (UA) of sample points used in CART® to produce the disturbance map.

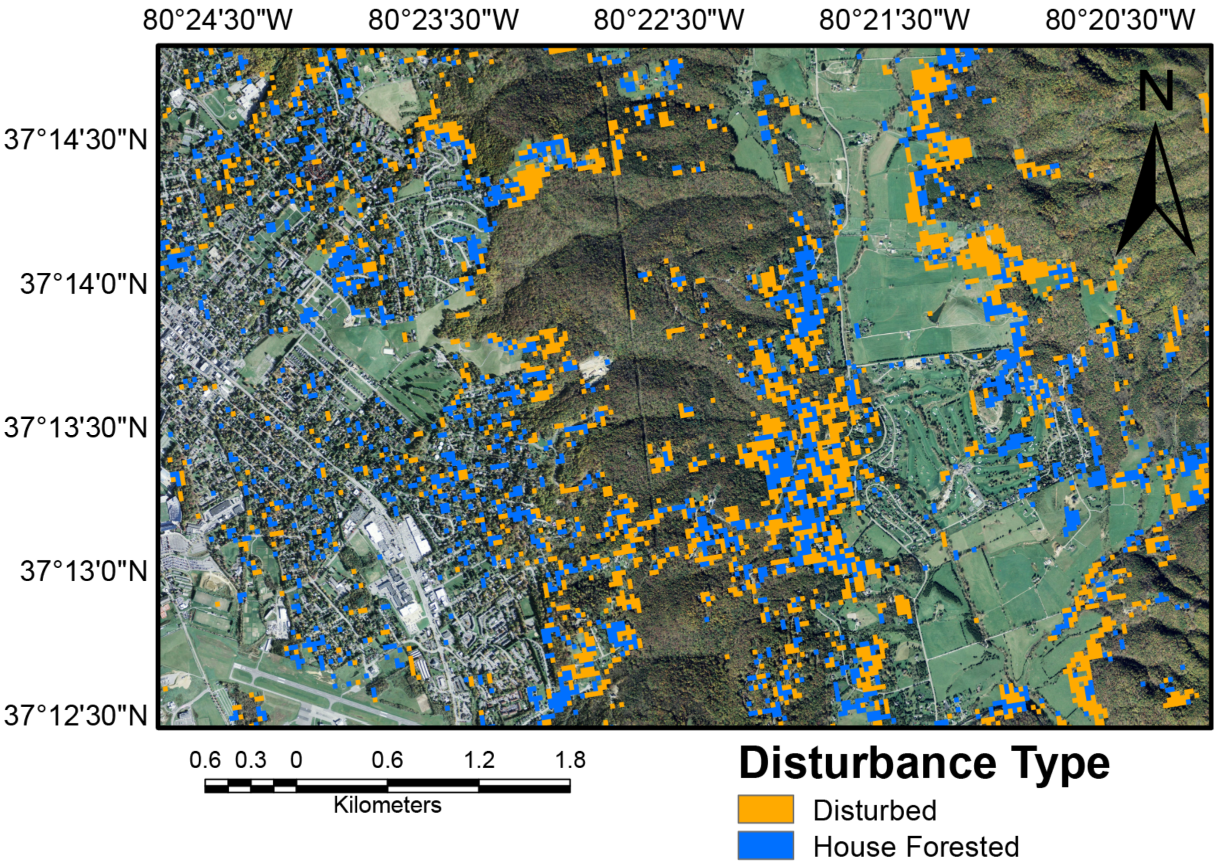
	House Forested	Disturbed	Total	UA (%)
House Forested	157	13	170	92.4
Disturbed	40	153	193	79.3
Total	197	166		
PA (%)	79.7	92.2		

Overall accuracy from the CART® model = 85.4 percent and the calculated F-statistic = 0.86

Together the two vectors produced an average prediction success of 85.9% with a cross-validated relative cost of 0.281, which is the error rate of the tree relative to the root node. A subset of the final map output is shown as figure 11.

Visual assessment of the resulting map exhibited signs of over-selecting for *Disturbed*. Many of the pixels labeled as *Disturbed* were found to frequently surround pixels labeled *House Forested*. This could explain why some *House Forested* points were classified as *Disturbed*. It also shows us that *Disturbed* and *House Forested* are quite distinct. If the pixel immediately adjacent to a known *House Forested* pixel is classified as *Disturbed* then it illustrates that we can correctly identify, on a pixel level, housing disturbances.

Figure 11. Map of disturbance classes displayed over the southeast Blacksburg, Virginia, USA. Blue represents *House Forested* and orange represents *Disturbed*. All other pixels are clear.



3.3 Forest Impacted due to Exurban Development by Virginia County and 6th Order Hydrologic Unit

Figures 12 and 14 show that where there are concentrations of people, more forest is being lost. The urban areas indicated typically have less forest cover to begin with, however the percentages account for this by only using forest as it was in the 1992 NLCD. Figure 13 represents the NLCD 2001 to 2011 Land Cover from to Change Index, where forest (class numbers: 41-Deciduous, 42-Evergreen, 43-Mixed, & 90-Woody Wetlands) change to developed (class numbers: 21-Developed Open Space, 22-Developed Low Intensity, 23-Medium Intensity, and 24-High Intensity) [30]. The legend for Figure 13 mirrors Figure 12. Figure 15 shows Figures 12 and Figure 14 together, in order to more clearly define where within a county the concentration of forest loss has occurred. Most national and state forests are on the west side of the Commonwealth, causing the western part to have smaller percentages of forest loss outside of the urban areas. Minimal additional forest conversion to housing (on a percentage basis) is occurring in the Hampton Roads area cities (e.g., Suffolk, Chesapeake, Norfolk, Portsmouth, Virginia Beach), in part because of the area covered by the Great Dismal Swamp and Back Bay Wildlife Refuges. In the Piedmont, extensive forest land is still actively managed, including the Appomattox-Buckingham State Forest, and development pressure has been less thus far than in the urban fringe.

Figure 12. D^3 derived map of percent forest impacted by exurban development by county and city for the Commonwealth of Virginia with 2010 Census urban areas overlay.

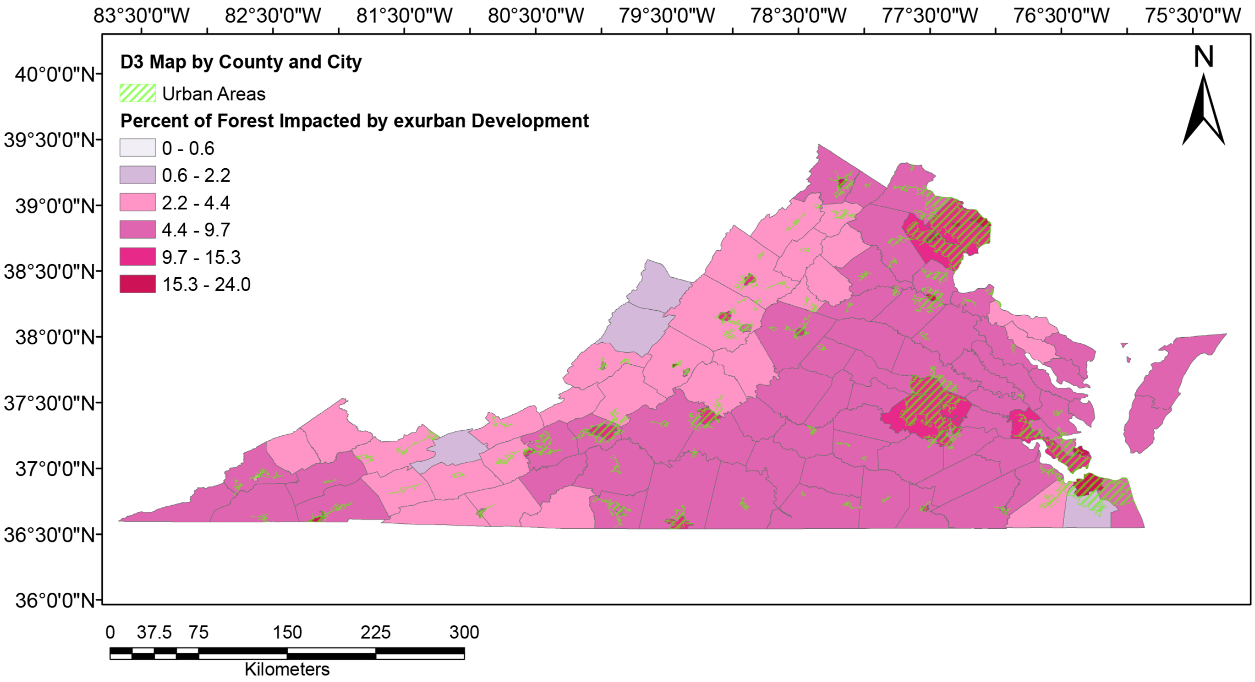


Figure 13. 2011 NLCD Change to Developed product of percent forest impacted by exurban development by county and city for the Commonwealth of Virginia with 2010 Census urban areas overlay.

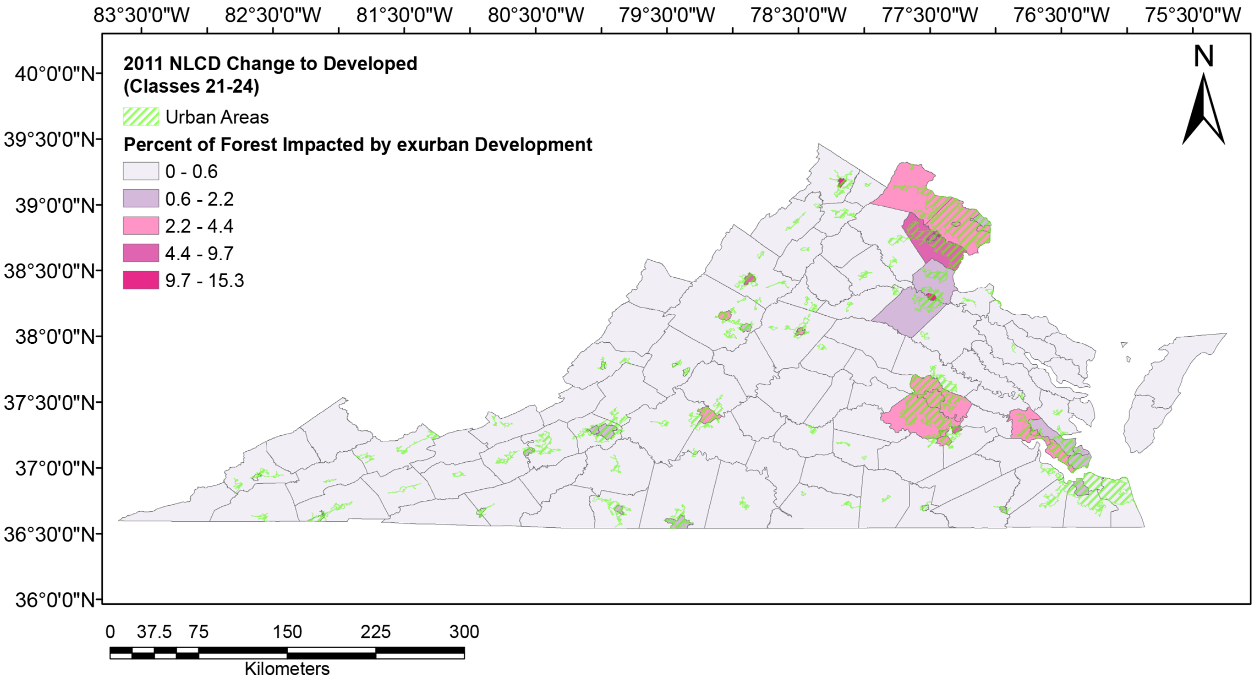


Figure 14. Percent forest impacted by exurban development by hydrologic unit code at the 12 digit hydrologic unit code level for the Commonwealth of Virginia with 2010 Census urban areas overlay.

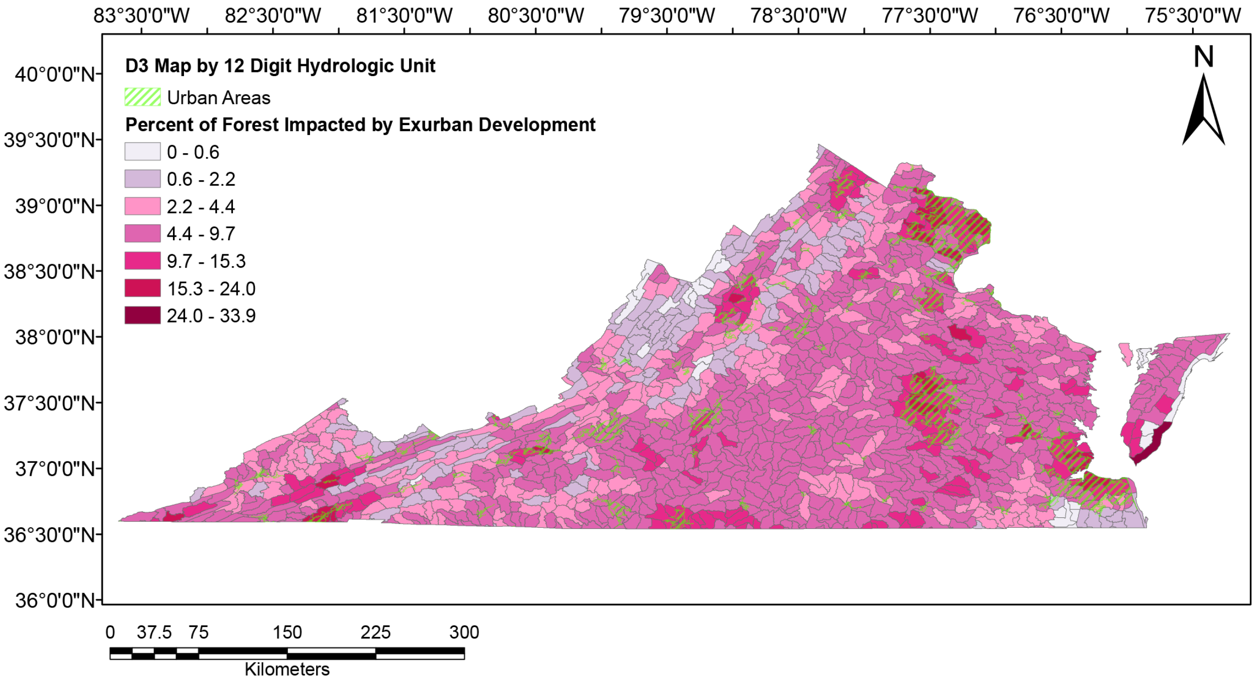
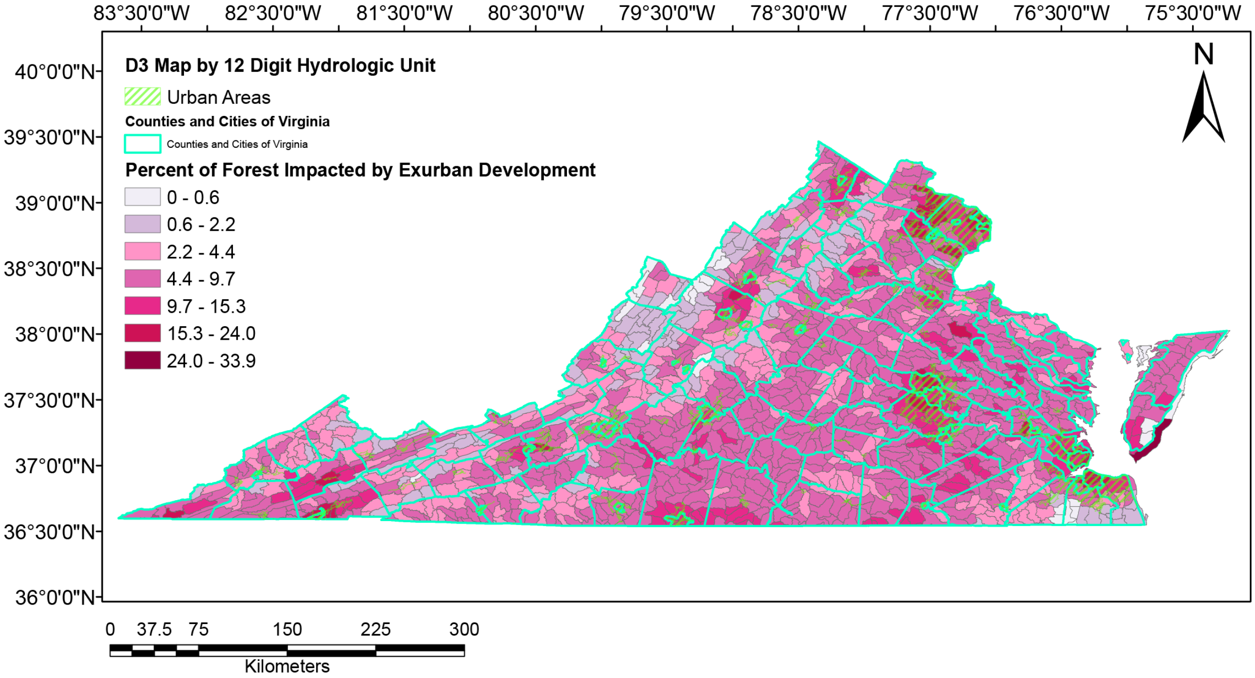


Figure 15. Percent forest impacted by exurban development by hydrologic unit code at the 12 digit hydrologic unit code level for the Commonwealth of Virginia with 2010 Census urban areas and County and City overlay.



4. Discussion

4.1. Review of Process and Results

Landsat time series stacks are useful in identifying disturbances to the forested landscape, because the temporal frequency of a single Landsat satellite (this study primarily used Landsat 5 TM) is relatively high at a 16-day interval. Others have been able to further increase the temporal frequency by blending data from different satellite platforms as well as using data from two Landsat satellites [31 & 32]. Algorithms using Landsat time series stacks have shown that they can separate disturbance types. We used a dense and chronological stack of Landsat images and converted each to NDVI to identify housing construction disturbances for the years 1995 to 2011.

Separation of *House Forested* and *Disturbed* is possible using only the highest NDVI reached post-disturbance and the slope from the lowest (non-cloud) NDVI value to the highest NDVI value post-disturbance. We were able to separate these two types of disturbance at a moderate level of accuracy. In contrast to other studies applying an object-based approach, the disturbances we were seeking were too small [18], i.e. the size of the disturbance is at or below the resolution of the sensor. It is what others consider noise that we were interested in identifying [16 & 33].

By using over 1300 images, as listed in Appendix A, and only using the maximum value per year, we could eliminate the need for precursor cloud screening (other than initial image selection). In addition to the richness of the image selection (recollect that all available reasonably cloud-free scenes were used), we applied two other cloud-focused elements to our algorithm. The first eliminated any NDVI value less than 0.4 from being identified as the disturbance. The second discarded initially flagged disturbances if the following year's NDVI value exceeded 0.81 (as, in practice, such rapid recovery was only observed to occur if the nominal disturbance was actually a cloud).

Our analysis illustrates that the Recovery Maximum (*High*) NDVI Value for *Disturbed* was typically higher than *House Forested*. For the Recovery Maximum (*High*) the variance in *House Forested* was considerable, as shown in Figure 10(c), and could not be used alone in separating disturbance types. There are nine instances from our training and validation dataset identified as Disturbed where the Recovery Maximum (*High*) did not recover to a value greater than .81. Seven of the nine instances are later years 2006-2008 (and thus did not have as much time to recover), as shown in Table 4.

There were no training data used from 2009-2011 due to the inability to calculate an adequate slope. The other two of the nine instances were forest harvests that did not get replanted immediately. With the addition of newer images from 2012 to the present, it is conceivable that these nine misclassified sample points could be correctly classified.

With the addition of the two cloud eliminating elements and other factors, the identified low is not always the initial year of disturbance. One solution to this could be to retroactively trace the trajectory back to the initial year the value fell below 0.76. This would allow for a more accurate prediction of when the disturbance occurred. This did not, however, affect the usefulness of D^3 in producing an accurate map of housing disturbance. The retracing of the low is a potential area of further investigation.

Table 4. The nine misclassified *Disturbed* sample points and potential reasons for the misclassification.

Classified As	Actual Class	Y	X	Year Disturbed	Recovery Maximum (High)	Information about Pixel
House Forested	Disturbed	36.730	-77.419	2003	0.784	not immediately revegetated coastal plain
House Forested	Disturbed	37.212	-77.113	2004	0.799	not immediately revegetated coastal plain
House Forested	Disturbed	36.749	-77.156	2006	0.756	stayed clear for a house built after 2011
House Forested	Disturbed	36.749	-79.512	2006	0.801	close to a clearing to pond
House Forested	Disturbed	36.674	-77.716	2007	0.729	xy between two different harvests 2003 and 2007
House Forested	Disturbed	36.957	-82.292	2007	0.794	Harvest then created runoff containment pond within pixel
House Forested	Disturbed	36.755	-77.235	2008	0.728	not immediately revegetated coastal plain
House Forested	Disturbed	37.002	-77.532	2008	0.754	not immediately revegetated coastal plain
House Forested	Disturbed	37.581	-78.811	2008	0.752	not immediately revegetated

4.2. Resulting Map and Comparison to the NLCD Change Product

As seen in Figure 16, our algorithm can detect isolated housing starts in previously forested areas (albeit with some commission error with respect to at least this housing data set). NLCD, in contrast, is only able to detect larger developments. Further, some of the NLCD-identified development is a development intensity increase rather than conversion from forested to developed classes (Figure 17). The difference between Figure 12 and Figure 13 can be explained by the method with which Homer et al. (2015) [30] derived the developed classes for the NLCD 2001 to 2011 Land Cover from to Change Index. They used Defense Meteorological Satellite Program (DMSP) nighttime lights imagery to exclude low density impervious areas outside urban areas in developing impervious surface products for 2001, 2006, and 2011. These three impervious layers (2001, 2006, and 2011) were categorized into the four developed classes. It can be seen in Figure 13 that where there are few urban areas there is less forest identified as impacted by exurban development according to the NLCD 2001 to 2011 Land Cover from to Change Index. Figure 16 indicates, markedly, that the methods used to derive the developed classes for NLCD preclude their products from identifying a majority of the exurban development we are concerned with finding.

Figure 16. Comparison of D^3-derived map and NLCD Change Product Map 2001-2011. This map represents an area of Blacksburg Virginia, USA.

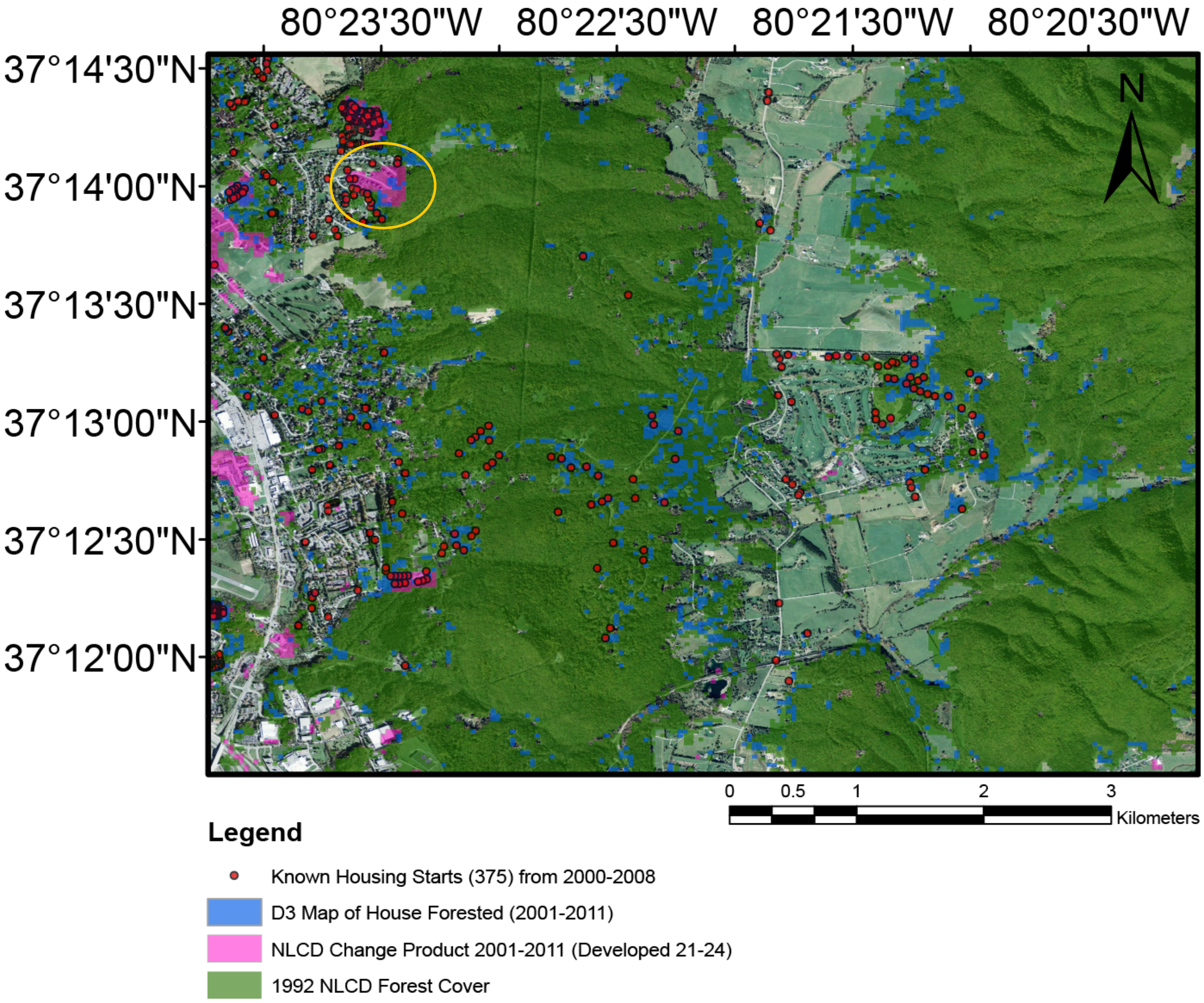
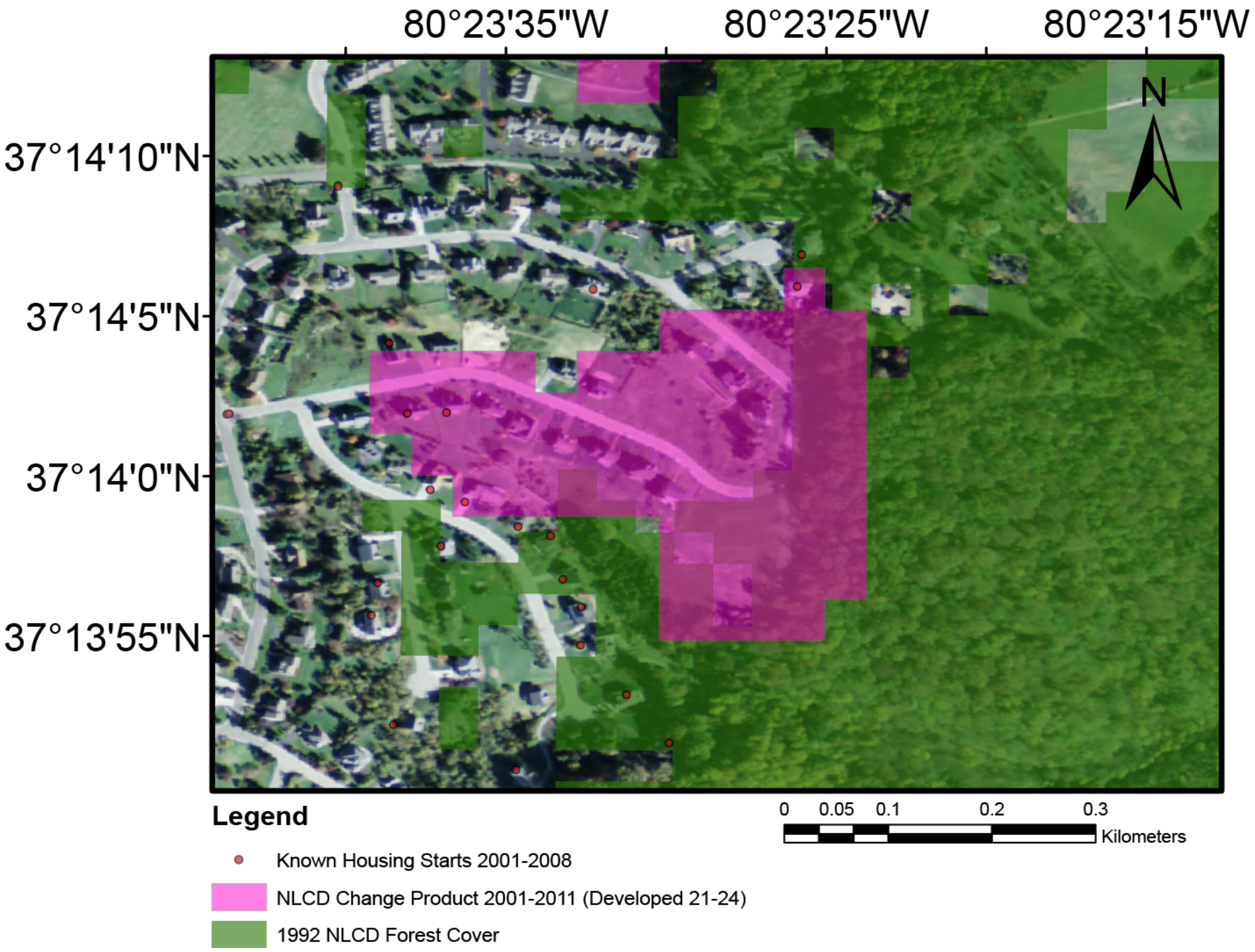


Figure 17. Detail image of area highlighted in Figure 16 by the orange circle.



Pixels offset due to original dataset projections. NLCD: Albert Conical Equal Area. The data frame for the window is WGS 1984.

5. Conclusions

Using an approach that identifies a forest disturbance and evaluates its post-disturbance trajectory is an excellent method for distinguishing disturbances due to housing starts from other causes of forest disturbance. In our analysis, the majority of the known classification errors were due to the temporal length being too short. 8 of the 9 disturbances misclassified as *House Forested* (Table 4) based on the *Recovery Maximum* (*High*) were spatially located on relatively flat terrain as viewed in Google Earth. Four of the nine points were located on the coastal plain of Virginia. These four were not replanted within the following two years. According to the Virginia Department of Forestry, "upon harvest closure any bare soils that are highly erodible or have a slope five percent or greater shall be immediately revegetated." It indicated no recommendation for soils on slopes of less than five percent [34 & 35]. Therefore the time between harvest and replanting on the coastal plain may be longer than that of areas with steeper topography. If misclassification due to the timeliness of replanting timber stands becomes a larger concern in the future, a possible solution could be to add the topographic layer and give weight to sample points with low topographical variability.

The Landsat archive is an enormous pool of data with which these type of analyses can be run. With the archive now being free to the public, large scale, image dense analyses can be more routinely conducted. A limiting factor is the time required to acquire and process enough images per path/row to conduct an effective analysis. With the advent of data lakes, an archive such as Landsat could be more readily accessible for image rich studies. This format would allow for the data scientist to specify parameters and then access the data on demand instead of being required to quasi-manually choose and acquire each image to a local storage repository.

Analyses using Landsat time series stacks have successfully been used by others to identify forest disturbances. Typically, these analyses used annual (one image per year) or biennial (one image per two years) Landsat time series stacks which required the researcher to be cognizant of cloud contamination and subsequent elimination [22]. By using as many images as we could process that were relatively cloud free, we have demonstrated that we can accurately separate disturbances due to development from other forest disturbances. There are other similar efforts that use all available data such as Exponentially Weighted Moving Average Change Detection (EWMACD) and Continuous Change Detection and Classification of land cover (CCDC) [23 & 32]. These both are effective in detecting disturbances to the forested landscape, however EWMACD and CCDC may be data and computationally overwhelming for the targeted stakeholders. CCDC identifies multiple types of change within their algorithm and requires 3 consecutive indications of change to identify a pixel as changed [32]. Our goal was to create a simple and accurate way to detect forest loss due to development. Many disturbances we identify as *House Forested* have the potential to be labeled as an orchard, bare soil, grassland, or pasture using CCDC. This analysis allows foresters and others a new opportunity to understand where development is occurring within the forested landscape and provides a tool with which they can develop a more tailored management strategy.

6. References

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Appendix A: List of Landsat Scenes

List of Landsat scenes used in study. Each scene has a unique scene ID such as LT50160352008185GNC01 courtesy of the U.S. Geological Survey. Using part of the scene ID, 160352008185, this table shows the Julian Date as month and day where each is uniquely labeled as **Path** **Row** **Year** **Month** **Day** identified by color scheme: **112233334455**

143419950312
143419950413
143419950429
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183420100520
183519960801
183519960817
183519970516
183519970703
183519970804
183519970905
183519980519
183519980620
183519980823
183519990607
183519990810
183519990911
183520000609
183520000625
183520000727
183520000812
183520010714
183520010730
183520020701
183520020717
183520020802
183520030602
183520030704
183520030720
183520040706
183520040807
183520040924
183520050709
183520050725
183520050911
183520060610

183420040620
183420040706
183420040807
183420040824
183420050522
183420050623
183420050701
183420050709
183420050802
183420050903
183420050911
183420050919
183420051029
183420060509
183420060525
183420060610
193519950705
193520010923
193520020505
193520020622
193520020809
193520020910
193520030609
193520030625
193519950822
193519950907
190520060703
193520030812
193520050918
193520060921
193520070924
193520080724
193520030913
193520070807
183420100621
183420100707
183420100808
183420100901
183420100909
183420110531
183420110608
183420110726
183420110811
183420110912
183420111030
183519950714
183519950815
183519950831
183519960630
183519960716
193520090625
193520100527
193520100831
193520110530
193520110802
193520110903
193519990902
193519980830
193519970624
193519970507
193519960520
193520040814
193520060617
193520070519
193520080521
193520080809
193520040611
193520070823
183520060712
183520070731
183520070816
183520070917
183520080717
183520080903
183520080919
183520090602
183520090805
183520100504
183520100621
183520100707
183520100909
183520110608
183520110726
183520110912
193520010822
193520010603
193520010619
193520000702
193520000531
193520000515
193519990817
193519980627
193519970523
193520050902
193519960621
193520050513
193520060719
193520070908
193520080606
193520070620
193520050614

Appendix B: Fortran Code for Virginia Tech Disturbance Program (D^3).

```
! ENVI Standard BSQ i/o
! Finds potential forest disturbance and calculates recovery metrics
!
!
! Randolph H. Wynne, FREC, Virginia Polytechnic Institute and State University
! Susmita Sen, FREC, Virginia Polytechnic Institute and State University
! Matthew House, FREC, Virginia Polytechnic Institute and State University
!
! Version 10, 02-Aug-16
!
program D3

use SVRGP_INT
implicit none

LOGICAL :: PixelNotWritten
LOGICAL :: NextYearAlsoDisturbed = .FALSE.
LOGICAL :: YearDisturbedIsLastYear = .FALSE.
LOGICAL :: FoundDisturbance = .FALSE.
LOGICAL :: OS = .FALSE.
LOGICAL :: Printed = .FALSE.
LOGICAL :: FirstSecondLow = .TRUE.

INTEGER, parameter :: REALKIND = 4, S_LEN = 32, STRINGBUFFER = 500, NEG1 = -1
INTEGER, parameter :: OUTNUMBANDS = 7
INTEGER (KIND = 8), parameter :: TEST_PIXEL = 20017380
INTEGER (KIND = 2) :: b ! NumBands
INTEGER (KIND = 2) :: IndexValue = 1
INTEGER (KIND = 2) :: MinRecoveryYears
INTEGER (KIND = 2) :: RecoveryYear
INTEGER (KIND = 2) :: MinYearsVegetation
INTEGER (KIND = 2) :: YearDisturbed = 0
INTEGER (KIND = 2) :: MinimumLocation = 0
INTEGER (KIND = 2) :: NumHeaderLines = 0
INTEGER (KIND = 2) :: CurrHeaderLineNum = 7
INTEGER (KIND = 2) :: NumLowValuesSearched
INTEGER (KIND = 8) :: Currx, Currx_fixed
INTEGER (KIND = 8) :: NumRecoveryYears
INTEGER (KIND = 8) :: NumRows, NumCols
INTEGER (KIND = 8) :: i, j, k, l, m, PostDisturbYear, LowValue ! Loop counters
INTEGER (KIND = 8) :: InRecLen, OutRecLen
REAL (KIND = 4) :: Threshold
REAL (KIND = 4) :: NextYearThreshold
REAL (KIND = 4) :: CloudThreshold
REAL (KIND = 4) :: Vegetation
```

```
REAL (KIND = 4) :: sxx, sxx_fixed
REAL (KIND = 4) :: sxy, sxy_fixed
REAL (KIND = 4) :: xm, xm_fixed
REAL (KIND = 4) :: ym, ym_fixed
REAL (KIND = 4) :: xsum, xsum_fixed
REAL (KIND = 4) :: ysum, ysum_fixed
REAL (KIND = 4) :: ysumshort !for recovery years only
REAL (KIND = 4) :: xres, xres_fixed
REAL (KIND = 4) :: yres, yres_fixed
REAL (KIND = 4) :: PixelSlope, PixelSlopeFixed
REAL (KIND = 4) :: CurrMax, CurrMin !,CurrValue, PrevValue, NextValue
REAL (KIND = 4) :: MinOne, MinTwo, MinThree
INTEGER (KIND = 4), ALLOCATABLE :: Indices (:)

REAL (KIND = 4), ALLOCATABLE :: UnsortedVector (:)
REAL (KIND = 4), ALLOCATABLE :: SortedVector (:)
REAL (KIND = 4), ALLOCATABLE :: x (:,:)
INTEGER (KIND = 4), ALLOCATABLE :: When (:)
REAL (KIND = 4), ALLOCATABLE :: WhenReal (:)
REAL (KIND = 4), ALLOCATABLE :: Slope (:)
REAL (KIND = 4), ALLOCATABLE :: Low (:)
REAL (KIND = 4), ALLOCATABLE :: High (:)
REAL (KIND = 4), ALLOCATABLE :: Average (:)
REAL (KIND = 4), ALLOCATABLE :: RecovPeriodSlope (:)
REAL (KIND = 4), ALLOCATABLE :: Forest (:)
REAL (KIND = 4), ALLOCATABLE :: AvgThreeMins(:)
CHARACTER (LEN = 4) :: ENVI = "ENVI"
CHARACTER (LEN = S_LEN) :: InputFileName
CHARACTER (LEN = S_LEN) :: InputHeaderFileName
CHARACTER (LEN = S_LEN) :: AbsoluteFileName
CHARACTER (LEN = S_LEN) :: AbsoluteHeaderFileName
CHARACTER (LEN = STRINGBUFFER) TempString

! The command line prompts in "" begin once D3 is called in command line interface on a
! windows desktop machine

PRINT *, "Input file name: "
read (unit = *, FMT = *) InputFileName
PRINT *, "Number of lines in header: "
read (unit = *, FMT = *) NumHeaderLines

PRINT *, "Output file name: "
read (unit = *, FMT = *) AbsoluteFileName

PRINT *, "Vegetation threshold: "
read (unit = *, FMT = *) Vegetation
```

```
PRINT *, "Minimum number of years at vegetation threshold"
read (unit = *, FMT = *) MinYearsVegetation
PRINT *, "Disturbance threshold: "
read (unit = *, FMT = *) Threshold
PRINT *, "Next year threshold: "
read (unit = *, FMT = *) NextYearThreshold

PRINT *, "Cloud threshold: "
read (unit = *, FMT = *) CloudThreshold

PRINT *, "Minimum number of years since disturbance: "
read (unit = *, FMT = *) MinRecoveryYears
PRINT *, "Number of low values searched: "
read (unit = *, FMT = *) NumLowValuesSearched

InputHeaderFileName = TRIM(InputFileName) // ".hdr"
! InputHeaderFileName = "sm.hdr"
PRINT *, "InputHeaderFileName"
PRINT *, "", InputHeaderFileName

AbsoluteHeaderFileName = TRIM(AbsoluteFileName) //".hdr"
PRINT *, "OutputHeaderFileName"
PRINT *, "", AbsoluteHeaderFileName

! last user required input is "OutputHeaderFileName"
! begin reading in header then, if successful, the input file

open (unit = 13, file = InputHeaderFileName, &
status = "old", action = "read")
INQUIRE (unit = 13, Opened=OS)
if (OS) then
PRINT *, "Input header file successfully opened."
end if

open (unit = 14, file = AbsoluteHeaderFileName, &
status = "replace", action = "write")

open (unit = 21, file = "debug.txt", &
status = "replace", action = "write")

read (unit = 13, fmt = "(A)") TempString
write (unit = 14, fmt = *) ENVI
PRINT *, ENVI

read (unit = 13, fmt = "(A)") TempString
```

```
write (unit = 14, fmt = "(A)") TRIM(ADJUSTL(TempString))
PRINT *, TRIM(TempString)

read (unit = 13, fmt = "(A)") TempString
write (unit = 14, fmt = "(A)") TRIM(ADJUSTL(TempString))
PRINT *, TRIM(TempString)

read (unit = 13, fmt = "(A10,I5)") TempString, NumCols
write (unit = 14, fmt = "(A10,I5)") TRIM (TempString), NumCols
PRINT *, TRIM (TempString), NumCols

read (unit = 13, fmt = "(A10,I5)") TempString, NumRows
write (unit = 14, fmt = "(A10,I5)") TRIM (TempString), NumRows
PRINT *, TRIM (TempString), NumRows

read (unit = 13, fmt = "(A10,I3)") TempString, b
write (unit = 14, fmt = "(A10,I3)") TRIM (TempString), OUTNUMBANDS
PRINT *, TRIM(TempString), b
CopyRestofHeader: do while (CurrHeaderLineNum .LE. NumHeaderLines)
read (unit = 13, fmt = "(A)") TempString
CurrHeaderLineNum = CurrHeaderLineNum + 1
write (unit = 14, fmt = "(A)") TRIM(ADJUSTL(TempString))
PRINT *,TRIM(TempString)
end do CopyRestofHeader
PRINT *, ""

CLOSE(13)
CLOSE (14)

! k = 16789 * 26214

k = NumRows * NumCols
OutRecLen = k * REALKIND !NumPixels * Bytes/Real
InRecLen = k * REALKIND !NumPixels * Bytes/Real

! matches input file size to output file size

write (unit = *, FMT = *) "Input file names: "
write (unit = *, FMT = *) " ", InputFileName
write (unit = *, FMT = *) "Number of Bands: "
write (unit = *, FMT = *) " ", b

write (unit = *, FMT = *) "Output file names: "
write (unit = *, FMT = *) " ", AbsoluteFileName
write (unit = *, FMT = *) "Record lengths (In, Out)"
```

```
write (unit = *, FMT = *) " ", InRecLen,OutRecLen

ALLOCATE (Indices (b))
ALLOCATE (UnsortedVector (b))
ALLOCATE (SortedVector (b))
ALLOCATE (x (k,b))
ALLOCATE (When (k))
ALLOCATE (WhenReal (k))
ALLOCATE (Slope (k))
ALLOCATE (Low (k))
ALLOCATE (High (k))
ALLOCATE (Average(k))
ALLOCATE (RecovPeriodSlope(k))
ALLOCATE (Forest (k))
ALLOCATE (AvgThreeMins(k))

x = 0.0
When = 0
WhenReal = 0.0
Slope = 0.0
Low = 0.0
High = 0.0
Average = 0.0
RecovPeriodSlope = 0.0
AvgThreeMins = 0.0
PixelNotWritten = .TRUE.

open (unit = 11, file = InputFileName, form = "unformatted", &
access = "direct", recl = InRecLen, status = "old", action = "read")

write (unit = *, fmt = *) "Reading input image into memory..."
ReadRawBandsLoop: do j = 1, b

read (unit = 11, rec = j) x (:,j)
end do ReadRawBandsLoop

close (unit = 11)
write (unit = *, fmt = *) "Input image read into memory."

PRINT *, "Calculating absolute thresholds and slopes"

LessThanFourTenthsAbs: do i = 1, k
IndexValue = 1
do m = 1, b
Indices (m) = IndexValue
IndexValue = IndexValue + 1
```

```
end do
UnsortedVector = 0.0
SortedVector = 0.0
NextYearAlsoDisturbed = .FALSE.
YearDisturbedIsLastYear = .FALSE.
FoundDisturbance = .FALSE.
MinimumLocation = 0

! If the pixel is vegetated and not a background pixel then proceed

VegPixelsOnly: if (((COUNT((x(i,:)).GT. Vegetation)) .GE. MinYearsVegetation) .AND.
(MINVAL (x(i,:)) .NE. 0.0)) then
UnsortedVector = x(i,:)
CALL SVRGP (UnsortedVector, SortedVector, Indices)

! Sorts a real array by algebraically increasing value and return the permutation that rearranges
! the array.

if ((Printed .EQ. .FALSE.) .OR. (i .EQ. TEST_PIXEL)) then
PRINT *, UnsortedVector
PRINT *, " "
PRINT *, SortedVector
PRINT *, " "
PRINT *, Indices
PRINT *, " "
end if
Forest (i) = 2.0
CurrMax = 0.0
CurrMin = 1.0
LowValue = 1

! Find a pair of low values starting from the lowest value, then proceeding to next lowest, etc.

FindPairofLowValues: do while ((LowValue .LE. NumLowValuesSearched) .AND.
(FoundDisturbance .EQ. .FALSE.))

! This is looking for the lowest value in the sorted vector and testing the value against two
! thresholds: the
! disturbance threshold and then the cloud threshold and then it checks to make sure the band(b)
! (year) is not
! the last in the series. (if b=17 then b cannot equal 17)

if ((SortedVector(LowValue) .LT. Threshold) .AND. (SortedVector(LowValue) .GT.
CloudThreshold)) then
MinimumLocation = Indices(LowValue)
if ((Printed .EQ. .FALSE.) .OR. (i .EQ. TEST_PIXEL)) then
```

```
PRINT *, "SortedVector(LowValue), Threshold, CloudThreshold, Indices(LowValue)", &
SortedVector(LowValue), Threshold, CloudThreshold, Indices(LowValue)
end if
if (MinimumLocation .EQ. b) then
YearDisturbedIsLastYear = .TRUE.
end if
if ((Printed .EQ. .FALSE.) .OR. (i .EQ. TEST_PIXEL)) then
PRINT *, "YearDisturbedIsLastYear", YearDisturbedIsLastYear
end if

! If the year disturbed is not the last year in the number of bands (b) in the file then the program
! takes the minimum
! location and adds a (1) year to it and checks that bands value against the next year threshold. If
! below the program
! says that year is also disturbed and that it has found the true disturbance.

if (YearDisturbedIsLastYear .NE. .TRUE.) then
if (x(i,MinimumLocation + 1) .LT. NextYearThreshold) then
NextYearAlsoDisturbed = .TRUE.
FoundDisturbance = .TRUE.
When(i) = MinimumLocation
YearDisturbed = MinimumLocation
end if
end if
if ((Printed .EQ. .FALSE.) .OR. (i .EQ. TEST_PIXEL)) then
PRINT *, "NextYearAlsoDisturbed, YearDisturbedIsLastYear"
PRINT *, "FoundDisturbance, When(i), YearDisturbed"
PRINT *, NextYearAlsoDisturbed, YearDisturbedIsLastYear, FoundDisturbance, &
When(i), YearDisturbed
if (LowValue .EQ. NumLowValuesSearched) then
Printed = .TRUE.
end if
end if
end if
LowValue = LowValue + 1
end do FindPairofLowValues

! If either the cloud threshold or year after threshold are not met the program loops to test the
! next lowest
! value in the sorted vectoras long as the LowValue is less than or equal to the user defined:
! NumLowValuesSearched

LowValueOnlyIfDisturbed: if (YearDisturbed .GT. 0) then
Low(i) = x(i,YearDisturbed)
END if LowValueOnlyIfDisturbed
```

```
! Only assign a low value if a value met all qualifications of the thresholds above.
! Compute Slopes if the pixel was assigned a low value and if the year disturbed less than or
! equal to the number of
! bands minus the user defined minimum number of recovery years

TrueSlope: if ( (YearDisturbed .GT. 0) .AND. ( (b-YearDisturbed) .GE. MinRecoveryYears) )
then

if (YearDisturbed .EQ. 0) then

PRINT *, "Should not be computing slopes with no disturbance!!!"
STOP

end if

sxx = 0.0
sxx_fixed = 0.0
sxy = 0.0
sxy_fixed = 0.0
Currx = 0
Currx_fixed = 0
xm = 0.0
xm_fixed = 0.0
ym = 0.0
ym_fixed = 0.0
xsum = 0.0
ysum = 0.0
xsum_fixed = 0.0
ysum_fixed = 0.0
ysumshort = 0.0
xres = 0.0
xres_fixed = 0.0
yres = 0.0
yres_fixed = 0.0
PixelSlope = 0.0
PixelSlopeFixed = 0.0
MinOne = 0.0
MinTwo = 0.0
MinThree = 0.0
PostDisturbYear = 0

! This finds the highest value in the timeseries that occurs after the recorded low value

FindRecoveryMax: do l = YearDisturbed, b

FindMaxAfterDisturbance: if (x(i,l) .GT. CurrMax) then
```

```
CurrMax = x(i,l)

end if FindMaxAfterDisturbance

High(i) = CurrMax
RecoveryYear = l
end do FindRecoveryMax


NumRecoveryYears = RecoveryYear - YearDisturbed

! Below finds the three lowest values in the time series

MinOne = Low(i)

do l = YearDisturbed, b
if ((x(i,l) .LT. CurrMin) .AND. (x(i,l) .GE. MinOne)) then
CurrMin = x(i,l)
end if
MinTwo = CurrMin
end do
CurrMin = 1.0
do l = YearDisturbed, b
if ((x(i,l) .LT. CurrMin) .AND. (x(i,l) .GE. MinTwo)) then
CurrMin = x(i,l)
end if
MinThree = CurrMin
end do
AvgThreeMins(i) = (MinOne+MinTwo+MinThree) / 3.0
CalculateSums: do l = YearDisturbed, RecoveryYear

PostDisturbYear = PostDisturbYear + 1
Currx = Currx + 1
xsum = xsum + Currx
ysum = ysum + x(i,l)
if (PostDisturbYear .EQ. MinRecoveryYears) then
xsum_fixed = xsum
ysum_fixed = ysum
end if
!
end do CalculateSums

CalculateSumMinRecoveryYears: do l = YearDisturbed+1, YearDisturbed + MinRecoveryYears
ysumshort = ysumshort + x(i,l)
end do CalculateSumMinRecoveryYears
```

```
! Calculate means

xm = xsum / (NumRecoveryYears)

ym = ysum / (NumRecoveryYears)

! Below computes the slope over the minimum number of recovery years.

Average(i) = ysumshort/MinRecoveryYears
Currx = 0

ComputeVarSlopePrecursors: do l = YearDisturbed, &
RecoveryYear

Currx = Currx + 1

xres = Currx - xm

yres = x(i,l) - ym

sxx = sxx + (xres * xres)

sxy = sxy + (xres * yres)


end do ComputeVarSlopePrecursors

ComputeFixedSlopePrecursors: do l = YearDisturbed+1, YearDisturbed + MinRecoveryYears
Currx_fixed = Currx_fixed + 1
xres_fixed = Currx_fixed - xm_fixed
yres_fixed = x(i,l) - ym_fixed
sxx_fixed = sxx_fixed + (xres_fixed * xres_fixed)
sxy_fixed = sxy_fixed + (xres_fixed * yres_fixed)
end do ComputeFixedSlopePrecursors
PixelSlopeFixed = sxy_fixed / sxx_fixed
PixelSlope = sxy / sxx
Slope(i) = PixelSlope
RecovPeriodSlope(i) = PixelSlopeFixed

end if TrueSlope



end if VegPixelsOnly
```

```
YearDisturbed = 0
END do LessThanFourTenthsAbs

! Program finished, now begin writing output file and header

PRINT *, "Absolute processing completed."
PRINT *, "First year set to zero for both absolute and difference."
PRINT *, "Opening output files."

open (unit = 10, file = AbsoluteFileName, form = "unformatted", &
access = 'direct', recl = OutRecLen, status = "replace", action = "write")

write (unit = *, fmt = *) "Output image files opened."
write (unit = *, fmt = *) "Writing output files."

WhenReal = REAL(When)

write (unit = 10, rec = 1) WhenReal

write (unit = 10, rec = 2) Slope
write (unit = 10, rec = 3) RecovPeriodSlope
write (unit = 10, rec = 4) Low

write (unit = 10, rec = 5) High

write (unit = 10, rec = 6) Average
write (unit = 10, rec = 7) AvgThreeMins

PRINT *, "Output image successfully written."
PRINT *, " "
PRINT *, "Output image band order:"
PRINT *, " Year of Disturbance"
PRINT *, " Slope to Maximum Post-Recovery Value"
PRINT *, " Slope over MinRecoveryYears"
PRINT *, " Low (value when first fell below threshold)"
PRINT *, " High (highest value within specified recovery period)"
PRINT *, " Average (in post mining recovery period)"
PRINT *, " Average of lowest three values in entire time series"
PRINT *, " "
close (unit = 10)
close (unit = 12)
close (unit = 21)
write (unit = *, fmt = *) "Output files written and closed."
write (unit = *, fmt = *) "D3 complete."

end program D3
```

Appendix C: Training dataset used to identify variables for D^3 and final dataset used in model to create disturbance map.

Reference	Y	X	Reference	Y	X
Agriculture	37.4462	-79.0847	Agriculture	37.1404	-79.8345
Agriculture	37.4083	-78.8759	Agriculture	37.2352	-79.7008
Agriculture	37.3364	-78.3223	Agriculture	37.0192	-79.7039
Agriculture	36.7913	-78.2480	Agriculture	37.6237	-79.5551
Agriculture	36.8040	-78.0118	Agriculture	37.8137	-79.3414
Agriculture	37.2857	-79.3426	Agriculture	37.7785	-79.3409
Agriculture	37.2294	-78.9164	Agriculture	37.8886	-77.7980
Agriculture	36.6710	-78.6748	Agriculture	37.0217	-79.9274
Agriculture	37.0556	-79.8453	Agriculture	37.4923	-79.8464
Agriculture	37.0325	-79.4544	Agriculture	36.6948	-79.0871
Agriculture	36.7513	-79.4577	Agriculture	36.8025	-79.7734
Agriculture	38.1320	-79.4243	Agriculture	37.7009	-78.9448
Agriculture	37.8973	-79.4252	Agriculture	37.6922	-78.6810
Agriculture	37.8391	-79.3191	Agriculture	37.3932	-79.7059
Agriculture	37.1483	-79.3068	Agriculture	36.5835	-79.7226
Agriculture	37.9822	-79.2738	Agriculture	37.4042	-79.6237
Agriculture	38.0390	-79.2560	Agriculture	38.2586	-78.8802
Agriculture	37.9826	-79.2058	Agriculture	36.5981	-78.2746
Agriculture	37.2353	-79.2081	Agriculture	38.1633	-77.8904
Agriculture	38.2534	-79.1666	Agriculture	36.9009	-79.0065
Agriculture	36.7622	-79.1953	Agriculture	36.5799	-79.6150
Agriculture	38.2650	-79.1498	Agriculture	38.3669	-77.9040
Agriculture	38.2785	-78.9996	Agriculture	38.2646	-79.6344
Agriculture	38.2222	-78.9960	Agriculture	38.1181	-79.0119
Agriculture	38.1738	-78.9028	Agriculture	38.3094	-78.1195
Agriculture	37.1155	-78.8817	Agriculture	38.2771	-78.9973
Agriculture	37.3919	-78.7500	Agriculture	38.1487	-77.9519
Agriculture	36.9073	-78.7047	Agriculture	37.7510	-79.5454
Agriculture	36.7997	-78.6780	Agriculture	38.1575	-78.5599
Agriculture	37.7474	-78.5986	Agriculture	37.3262	-78.1950
Agriculture	37.9412	-78.5101	Agriculture	36.8055	-78.4468
Agriculture	37.4375	-78.4065	Agriculture	37.0216	-79.8279
Agriculture	36.8759	-78.4007	Agriculture	37.9095	-77.7224
Agriculture	37.9697	-78.3148	Agriculture	38.2326	-78.1290
Agriculture	37.9132	-77.8570	Agriculture	37.0257	-77.4722
Agriculture	38.2969	-79.4636	Agriculture	38.4277	-79.5237
Agriculture	36.6412	-78.7609	Agriculture	37.2805	-79.6337
Agriculture	37.7618	-78.6040	Agriculture	38.3062	-77.9508
Agriculture	38.0638	-78.1681	Agriculture	37.8593	-78.1613
Agriculture	36.9315	-78.4581	Agriculture	37.3670	-78.5224
Agriculture	37.0495	-78.7443	Agriculture	36.5183	-78.2503
Agriculture	36.6897	-78.3782	Agriculture	38.2948	-80.0345
Agriculture	38.1649	-79.2308	Agriculture	37.0010	-79.7729

Reference	Y	X	Reference	Y	X
Agriculture	37.3574	-79.8776	Agriculture	37.9231	-78.2179
Agriculture	36.6752	-78.9197	Agriculture	37.5071	-77.7730
Agriculture	37.6556	-80.1717	Agriculture	37.7167	-78.1576
Agriculture	37.9949	-79.1481	Agriculture	38.3574	-78.8615
Agriculture	37.0775	-78.7387	Agriculture	37.7669	-79.4985
Agriculture	37.4071	-77.5906	Agriculture	37.7901	-77.6476
Agriculture	38.1435	-77.8676	Agriculture	36.9918	-79.7421
Agriculture	38.2369	-79.6887	Agriculture	37.2719	-79.7432
Agriculture	38.2395	-77.7038	Agriculture	38.2307	-79.0640
Agriculture	38.1825	-79.4424	Agriculture	37.5170	-79.8046
Agriculture	37.5762	-79.7208	Agriculture	38.2912	-79.1488
Agriculture	37.9243	-79.3990	Agriculture	38.2631	-78.8632
Agriculture	38.4201	-77.8220	Agriculture	38.0072	-78.1635
Agriculture	38.1434	-78.9732	Agriculture	38.1130	-79.6170
Agriculture	37.2588	-79.1345	Agriculture	37.3299	-79.4344
Agriculture	36.6379	-78.9989	Agriculture	38.2520	-78.8444
Agriculture	37.5239	-79.9304	Disturbed Harvest	36.7437	-77.5611
Agriculture	37.8306	-79.3540	Disturbed Harvest	36.8835	-78.0330
Agriculture	37.4869	-79.8468	Disturbed Harvest	37.7972	-77.8275
Agriculture	36.7239	-80.0784	Disturbed Thin	38.1806	-77.7732
Agriculture	36.9407	-78.9327	Disturbed Thin	37.9013	-78.4128
Agriculture	37.3143	-78.5343	Disturbed Harvest	37.4878	-78.7763
Agriculture	37.1938	-78.9015	Disturbed Harvest	37.8791	-78.4842
Agriculture	36.9743	-77.9274	Disturbed Harvest	37.1460	-77.9083
Agriculture	36.6425	-78.2872	Disturbed Harvest	37.5906	-79.8082
Agriculture	37.1341	-79.2588	Disturbed Harvest	37.5106	-78.0979
Agriculture	37.2426	-79.6554	Disturbed Harvest	37.9938	-78.0810
Agriculture	37.3940	-79.3172	Disturbed Harvest	37.8203	-78.6365
Agriculture	37.6249	-78.5737	Disturbed Harvest	38.2300	-78.8426
Agriculture	37.0066	-79.7074	Disturbed Harvest	37.4551	-78.0390
Agriculture	38.3782	-77.9959	Disturbed Harvest	37.2775	-79.3553
Agriculture	36.5618	-80.1722	Disturbed Harvest	38.2487	-79.3405
Agriculture	37.1293	-79.5899	Disturbed Harvest	37.9001	-77.7255
Agriculture	38.4503	-78.2600	Disturbed Harvest	37.3168	-78.6293
Agriculture	36.7901	-79.3133	Disturbed Harvest	37.5852	-78.4320
Agriculture	37.7514	-78.1368	Disturbed Harvest	38.0691	-78.1190
Agriculture	37.7273	-78.2395	Disturbed Harvest	38.0967	-78.1193
Agriculture	37.0868	-78.9065	Disturbed Harvest	37.9236	-78.7359
Agriculture	38.1940	-78.3265	Disturbed Harvest	37.8372	-78.9018
Agriculture	37.1509	-79.6283	Disturbed Harvest	38.2088	-78.6898
Agriculture	37.2419	-78.6564	Disturbed Harvest	36.9292	-79.5656
Agriculture	38.0140	-79.3359	Disturbed Harvest	36.7911	-79.5483
Agriculture	36.5431	-79.5892	Disturbed Harvest	37.3777	-77.9503

Reference	Y	X	Reference	Y	X
Disturbed Harvest	36.8314	-78.7490	Disturbed Harvest	37.0437	-78.0847
Disturbed Harvest	37.3060	-78.3041	Disturbed Harvest	38.2937	-77.5028
Disturbed Harvest	37.8633	-77.9634	Disturbed Harvest	37.8059	-78.4271
Disturbed Harvest	36.8410	-78.8634	Disturbed Harvest	36.5139	-78.5563
Disturbed Harvest	37.5499	-78.3300	Disturbed Harvest	36.9849	-78.2835
Disturbed Harvest	36.7559	-78.3053	Disturbed Harvest	36.7643	-78.6764
Disturbed Harvest	37.1414	-78.1323	Disturbed Harvest	37.3310	-78.6093
Disturbed Harvest	37.5865	-78.6364	Disturbed Harvest	36.5919	-77.6878
Disturbed Harvest	36.5875	-78.0785	Disturbed Harvest	36.7566	-78.8446
Disturbed Harvest	36.8427	-78.8476	Disturbed Harvest	38.1240	-78.0888
Disturbed Harvest	36.7424	-78.3424	Disturbed Harvest	37.2974	-78.1880
Disturbed Harvest	37.8531	-78.9420	Disturbed Harvest	37.5507	-80.1338
Disturbed Harvest	37.6201	-78.7938	Disturbed Harvest	37.2115	-77.6893
Disturbed Harvest	38.0549	-78.0170	Disturbed Harvest	36.6277	-78.0522
Disturbed Harvest	38.3379	-79.1912	Disturbed Harvest	36.5513	-79.9098
Disturbed Harvest	36.9461	-79.4912	Disturbed Harvest	36.5274	-77.6139
Disturbed Harvest	37.1259	-78.9487	Disturbed Harvest	36.8810	-79.2777
Disturbed Harvest	36.6518	-78.4281	Disturbed Harvest	36.7509	-78.4970
Disturbed Harvest	36.9320	-78.5979	Disturbed Harvest	36.8758	-79.6241
Disturbed Harvest	36.9307	-78.0955	Disturbed Harvest	37.1563	-79.3147
Disturbed Harvest	37.1695	-78.5120	Disturbed Harvest	37.1486	-78.2749
Disturbed Harvest	37.0618	-78.5105	Disturbed Harvest	38.1430	-79.2467
Disturbed Harvest	37.5405	-78.7184	Disturbed Harvest	37.4473	-78.5489
Disturbed Harvest	37.3081	-78.2874	Disturbed Harvest	36.4710	-78.1218
Disturbed Harvest	37.0218	-79.4030	Disturbed Harvest	37.4645	-78.7295
Disturbed Harvest	37.3177	-77.9716	Disturbed Harvest	37.3682	-78.2443
Disturbed Harvest	37.9617	-78.3318	Disturbed Harvest	36.9750	-79.0757
Disturbed Harvest	37.1905	-79.0250	Disturbed Harvest	37.2329	-77.6718
Disturbed Harvest	36.5596	-79.5909	Disturbed Harvest	37.0579	-78.3541
Disturbed Harvest	36.7540	-77.9560	Disturbed Harvest	37.5117	-78.7111
Disturbed Harvest	36.6222	-79.9182	Disturbed Harvest	38.1554	-78.1327
Disturbed Harvest	37.1818	-77.6524	Disturbed Harvest	36.9795	-78.6385
Disturbed Harvest	37.7984	-78.5949	Disturbed Harvest	36.9498	-78.3187
Disturbed Harvest	37.2272	-77.5862	Disturbed Harvest	37.3685	-78.9983
Disturbed Harvest	37.1556	-79.7870	Disturbed Harvest	36.8522	-79.2874
Disturbed Harvest	38.0881	-77.5786	Disturbed Harvest	38.0330	-78.0487
Disturbed Harvest	36.9054	-79.0367	Disturbed Harvest	36.6863	-77.4921
Disturbed Harvest	37.7105	-78.5277	Disturbed Harvest	37.2448	-77.6246
Disturbed Harvest	38.1680	-77.6790	Disturbed Harvest	36.8913	-78.9701
Disturbed Harvest	36.7841	-79.3642	Disturbed Harvest	37.3293	-78.4394
Disturbed Harvest	37.6088	-78.4121	Disturbed Harvest	37.8038	-78.5951
Disturbed Harvest	37.3164	-77.5862	Disturbed Thin	37.4215	-79.8553
Disturbed Harvest	36.5892	-79.2537	Disturbed Thin	38.2801	-79.4811

Reference	Y	X	Reference	Y	X
Disturbed Thin	36.7021	-78.8512	Forest	36.8469	-80.0022
Disturbed Thin	36.6968	-78.8104	Forest	36.9012	-79.9978
Disturbed Thin	37.9001	-78.1488	Forest	36.9012	-79.9978
Disturbed Thin	36.8031	-78.1480	Forest	36.9530	-79.9806
Disturbed Thin	37.6301	-78.0086	Forest	36.9530	-79.9806
Disturbed Thin	37.8577	-77.9469	Forest	36.8947	-79.9379
Disturbed Thin	37.2225	-77.8977	Forest	36.9643	-79.9218
Disturbed Thin	37.1793	-79.1334	Forest	36.9643	-79.9218
Disturbed Thin	36.8373	-78.3775	Forest	37.1925	-79.9111
Disturbed Thin	36.6208	-78.4546	Forest	37.0247	-79.8980
Disturbed Thin	38.0662	-79.4189	Forest	36.8277	-79.8867
Disturbed Thin	36.9153	-78.3486	Forest	37.3563	-79.8739
Disturbed Thin	37.1292	-79.5541	Forest	37.3563	-79.8739
Disturbed Thin	37.5592	-78.5086	Forest	37.3792	-79.8708
Disturbed Thin	37.1331	-78.2376	Forest	37.1380	-79.8734
Disturbed Thin	36.6789	-78.0798	Forest	37.1380	-79.8734
Disturbed Thin	37.9054	-79.1432	Forest	37.3962	-79.8353
Disturbed Thin	37.8148	-78.2482	Forest	37.3042	-79.8313
Disturbed Thin	37.6061	-78.5910	Forest	37.3042	-79.8313
Disturbed Thin	37.8551	-78.8287	Forest	37.5977	-79.8189
Disturbed Thin	37.0868	-78.3156	Forest	37.2143	-79.8219
Disturbed Thin	36.6572	-78.1306	Forest	37.0732	-79.8200
Disturbed Thin	37.2950	-78.8625	Forest	37.2784	-79.8145
Disturbed Thin	36.5859	-77.7658	Forest	37.3997	-79.8126
Disturbed Thin	37.6255	-78.4452	Forest	37.2784	-79.8145
Disturbed Thin	36.7038	-77.9090	Forest	37.6379	-79.8084
Disturbed Thin	37.2490	-80.0757	Forest	37.5906	-79.8082
Disturbed Thin	36.8408	-77.6670	Forest	37.0530	-79.8085
Disturbed Thin	36.8871	-78.5215	Forest	37.4735	-79.8019
Disturbed Thin	37.8930	-78.7290	Forest	37.0530	-79.8085
Disturbed Thin	38.0775	-77.6229	Forest	37.7078	-79.7954
Disturbed Thin	38.0318	-79.8547	Forest	37.7078	-79.7954
Disturbed Thin	37.1416	-78.9962	Forest	37.2806	-79.7972
Disturbed Thin	36.6713	-79.2142	Forest	37.1369	-79.7859
Disturbed Thin	36.8631	-78.4829	Forest	37.1369	-79.7859
Disturbed Thin	37.8514	-79.3484	Forest	37.3213	-79.7823
Disturbed Thin	37.9095	-77.7135	Forest	37.3213	-79.7823
Disturbed Thin	37.6785	-77.9778	Forest	37.3815	-79.7773
Disturbed Thin	37.8518	-78.3511	Forest	37.3866	-79.7748
Disturbed Thin	36.6622	-77.6388	Forest	37.3477	-79.7697
Disturbed Thin	37.4378	-78.6788	Forest	37.3477	-79.7697
Disturbed Thin	37.4113	-79.4561	Forest	37.5769	-79.7612
Disturbed Thin	38.0099	-77.5741	Forest	36.8025	-79.7734

Reference	Y	X	Reference	Y	X
Forest	37.6479	-79.7576	Forest	37.9340	-79.6313
Forest	37.8320	-79.7545	Forest	37.9340	-79.6313
Forest	37.6479	-79.7576	Forest	37.6909	-79.6354
Forest	36.9674	-79.7681	Forest	37.6909	-79.6354
Forest	37.3643	-79.7562	Forest	37.8207	-79.6324
Forest	36.9062	-79.7529	Forest	37.8827	-79.6206
Forest	37.0962	-79.7481	Forest	36.8122	-79.6381
Forest	37.0962	-79.7481	Forest	38.0370	-79.6140
Forest	37.9181	-79.7152	Forest	38.0370	-79.6140
Forest	37.0417	-79.7288	Forest	37.4671	-79.6198
Forest	37.7469	-79.7120	Forest	37.9499	-79.6081
Forest	37.9205	-79.7073	Forest	37.9499	-79.6081
Forest	37.5817	-79.7111	Forest	37.4571	-79.6129
Forest	37.5817	-79.7111	Forest	38.1101	-79.5982
Forest	37.3990	-79.7126	Forest	38.1101	-79.5982
Forest	37.3990	-79.7126	Forest	36.8379	-79.6188
Forest	37.3391	-79.7028	Forest	36.8379	-79.6188
Forest	37.8814	-79.6920	Forest	37.4164	-79.6052
Forest	37.8814	-79.6920	Forest	37.4164	-79.6052
Forest	37.5572	-79.6888	Forest	38.2357	-79.5866
Forest	36.8809	-79.6924	Forest	38.0848	-79.5826
Forest	37.2569	-79.6829	Forest	38.3375	-79.5777
Forest	37.6560	-79.6755	Forest	37.5463	-79.5912
Forest	37.6089	-79.6760	Forest	37.5463	-79.5912
Forest	37.6089	-79.6760	Forest	38.1261	-79.5777
Forest	36.9774	-79.6847	Forest	38.1261	-79.5777
Forest	37.5180	-79.6735	Forest	37.7547	-79.5839
Forest	37.7397	-79.6686	Forest	38.1484	-79.5715
Forest	37.7397	-79.6686	Forest	38.0173	-79.5710
Forest	37.3915	-79.6744	Forest	37.9186	-79.5688
Forest	37.3915	-79.6744	Forest	37.8261	-79.5661
Forest	37.6775	-79.6687	Forest	37.7188	-79.5648
Forest	38.1321	-79.6560	Forest	37.9076	-79.5560
Forest	38.1321	-79.6560	Forest	37.9076	-79.5560
Forest	37.7626	-79.6620	Forest	37.1292	-79.5541
Forest	37.7626	-79.6620	Forest	37.5040	-79.5391
Forest	37.8134	-79.6598	Forest	37.0028	-79.5453
Forest	37.2494	-79.6634	Forest	37.8072	-79.5253
Forest	37.9154	-79.6419	Forest	37.8072	-79.5253
Forest	37.9154	-79.6419	Forest	38.0567	-79.5196
Forest	37.8367	-79.6406	Forest	37.9374	-79.5131
Forest	37.8367	-79.6406	Forest	36.9769	-79.5283
Forest	37.2111	-79.6485	Forest	38.3770	-79.4969

Reference	Y	X	Reference	Y	X
Forest	37.9746	-79.5024	Forest	38.0567	-79.3404
Forest	36.9046	-79.5216	Forest	37.5548	-79.3482
Forest	36.9046	-79.5216	Forest	37.4906	-79.3411
Forest	37.4323	-79.5079	Forest	37.1386	-79.3465
Forest	36.7480	-79.5176	Forest	38.2713	-79.3132
Forest	38.2801	-79.4811	Forest	37.6742	-79.3231
Forest	37.6440	-79.4901	Forest	37.4828	-79.3254
Forest	38.2286	-79.4716	Forest	37.4828	-79.3254
Forest	37.2743	-79.4840	Forest	37.1003	-79.3291
Forest	37.2743	-79.4840	Forest	37.7608	-79.3096
Forest	37.0477	-79.4858	Forest	38.2207	-79.2942
Forest	37.2429	-79.4775	Forest	38.2275	-79.2937
Forest	38.0056	-79.4571	Forest	38.2275	-79.2937
Forest	38.3637	-79.4443	Forest	37.7074	-79.2979
Forest	37.5979	-79.4567	Forest	38.0803	-79.2879
Forest	37.3438	-79.4599	Forest	37.6286	-79.2902
Forest	37.4113	-79.4561	Forest	37.6050	-79.2876
Forest	37.1588	-79.4613	Forest	37.5196	-79.2889
Forest	37.1588	-79.4613	Forest	37.5820	-79.2841
Forest	37.5911	-79.4334	Forest	37.5820	-79.2841
Forest	38.0662	-79.4189	Forest	37.9244	-79.2738
Forest	37.4547	-79.4264	Forest	37.3962	-79.2856
Forest	37.1522	-79.4290	Forest	38.3553	-79.2564
Forest	37.1522	-79.4290	Forest	37.6437	-79.2708
Forest	38.3222	-79.3937	Forest	37.6472	-79.2703
Forest	38.2523	-79.3874	Forest	37.8748	-79.2650
Forest	38.2690	-79.3795	Forest	38.3109	-79.2471
Forest	37.7616	-79.3893	Forest	37.2265	-79.2715
Forest	36.8366	-79.4085	Forest	37.2265	-79.2715
Forest	36.8366	-79.4085	Forest	37.1693	-79.2411
Forest	37.3716	-79.3970	Forest	37.0604	-79.2298
Forest	37.3716	-79.3970	Forest	38.3379	-79.1912
Forest	37.8926	-79.3779	Forest	38.0937	-79.1897
Forest	37.8926	-79.3779	Forest	38.2972	-79.1833
Forest	38.1030	-79.3616	Forest	36.7458	-79.2185
Forest	37.0882	-79.3749	Forest	37.4066	-79.2020
Forest	38.3677	-79.3464	Forest	37.8269	-79.1918
Forest	38.3677	-79.3464	Forest	37.8269	-79.1918
Forest	37.2216	-79.3667	Forest	37.7138	-79.1878
Forest	37.2216	-79.3667	Forest	37.1165	-79.1984
Forest	37.6927	-79.3533	Forest	38.0745	-79.1724
Forest	38.2487	-79.3405	Forest	37.5001	-79.1818
Forest	38.0265	-79.3435	Forest	37.1990	-79.1826

Reference	Y	X	Reference	Y	X
Forest	37.6354	-79.1530	Forest	36.7348	-78.9564
Forest	37.6354	-79.1530	Forest	36.9134	-78.9503
Forest	37.9054	-79.1432	Forest	37.8372	-78.9018
Forest	38.0001	-79.1305	Forest	37.1473	-78.9018
Forest	37.1793	-79.1334	Forest	37.2115	-78.8936
Forest	36.8916	-79.1387	Forest	37.4620	-78.8856
Forest	36.8292	-79.1369	Forest	37.4620	-78.8856
Forest	37.9951	-79.1068	Forest	37.9231	-78.8687
Forest	36.8640	-79.1313	Forest	36.9927	-78.8916
Forest	37.8391	-79.1070	Forest	37.2263	-78.8763
Forest	37.8391	-79.1070	Forest	37.2263	-78.8763
Forest	37.9809	-79.1017	Forest	37.6767	-78.8618
Forest	36.9361	-79.1262	Forest	37.8591	-78.8542
Forest	37.0176	-79.1171	Forest	38.2300	-78.8426
Forest	37.3719	-79.1063	Forest	36.7461	-78.8778
Forest	36.6929	-79.1207	Forest	37.2950	-78.8625
Forest	37.5156	-79.0962	Forest	36.7461	-78.8778
Forest	37.0236	-79.1065	Forest	37.3176	-78.8551
Forest	37.4103	-79.0918	Forest	36.8410	-78.8634
Forest	37.8298	-79.0701	Forest	37.8551	-78.8287
Forest	38.2881	-79.0573	Forest	38.2744	-78.8139
Forest	36.8023	-79.0801	Forest	36.7021	-78.8512
Forest	37.6633	-79.0564	Forest	38.0537	-78.8109
Forest	37.3520	-79.0638	Forest	37.9145	-78.8113
Forest	37.6410	-79.0474	Forest	37.9145	-78.8113
Forest	37.6410	-79.0474	Forest	37.0324	-78.8281
Forest	37.6258	-79.0407	Forest	38.0785	-78.7927
Forest	37.1993	-79.0345	Forest	38.0785	-78.7927
Forest	37.5476	-79.0203	Forest	37.6783	-78.8012
Forest	37.4558	-79.0133	Forest	37.4516	-78.8052
Forest	37.4558	-79.0133	Forest	38.0673	-78.7865
Forest	37.2351	-79.0120	Forest	37.0148	-78.8148
Forest	36.7675	-79.0174	Forest	37.6635	-78.7918
Forest	37.6509	-78.9904	Forest	36.6968	-78.8104
Forest	37.9513	-78.9802	Forest	38.1078	-78.7668
Forest	37.8835	-78.9810	Forest	38.0624	-78.7672
Forest	37.8786	-78.9631	Forest	37.8808	-78.7720
Forest	37.0932	-78.9634	Forest	38.0358	-78.7639
Forest	37.0932	-78.9634	Forest	37.8658	-78.7673
Forest	37.8531	-78.9420	Forest	37.8658	-78.7673
Forest	37.0926	-78.9597	Forest	37.4878	-78.7763
Forest	37.5309	-78.9441	Forest	37.5664	-78.7739
Forest	37.6726	-78.9320	Forest	37.7503	-78.7630

Reference	Y	X	Reference	Y	X
Forest	36.7670	-78.7916	Forest	37.3236	-78.5672
Forest	37.3855	-78.7725	Forest	37.5270	-78.5596
Forest	38.0578	-78.7407	Forest	37.6236	-78.5493
Forest	37.2609	-78.7583	Forest	37.4899	-78.5523
Forest	37.9236	-78.7359	Forest	37.4427	-78.5481
Forest	38.1387	-78.7289	Forest	37.4048	-78.5330
Forest	36.8314	-78.7490	Forest	36.7445	-78.5513
Forest	38.1298	-78.7042	Forest	37.8422	-78.5039
Forest	36.7232	-78.7468	Forest	37.5592	-78.5086
Forest	38.1298	-78.7042	Forest	37.9760	-78.4901
Forest	37.5405	-78.7184	Forest	37.4067	-78.5065
Forest	38.1075	-78.6981	Forest	37.1609	-78.5146
Forest	38.1075	-78.6981	Forest	37.1681	-78.5120
Forest	38.2088	-78.6898	Forest	37.1695	-78.5120
Forest	36.9822	-78.7213	Forest	37.8791	-78.4842
Forest	37.8052	-78.6935	Forest	37.0618	-78.5105
Forest	37.8052	-78.6935	Forest	37.7941	-78.4823
Forest	36.9073	-78.7047	Forest	37.7941	-78.4823
Forest	37.7313	-78.6764	Forest	37.1221	-78.4855
Forest	37.4203	-78.6817	Forest	37.1221	-78.4855
Forest	37.8359	-78.6571	Forest	37.9216	-78.4497
Forest	36.7059	-78.6771	Forest	37.5304	-78.4624
Forest	36.7059	-78.6771	Forest	37.5304	-78.4624
Forest	37.6678	-78.6464	Forest	36.9927	-78.4777
Forest	38.0492	-78.6329	Forest	37.2656	-78.4581
Forest	38.2645	-78.6235	Forest	37.4163	-78.4489
Forest	37.6497	-78.6371	Forest	38.2042	-78.4200
Forest	37.6497	-78.6371	Forest	38.1233	-78.4153
Forest	37.5865	-78.6364	Forest	38.1233	-78.4153
Forest	38.1322	-78.6186	Forest	36.8814	-78.4561
Forest	38.1322	-78.6186	Forest	37.5852	-78.4320
Forest	38.0013	-78.6146	Forest	36.6964	-78.4518
Forest	37.0383	-78.6427	Forest	37.8372	-78.4113
Forest	37.0383	-78.6427	Forest	37.5562	-78.4167
Forest	36.8399	-78.6445	Forest	37.0507	-78.4326
Forest	36.8399	-78.6445	Forest	37.7606	-78.3925
Forest	37.3168	-78.6293	Forest	37.8951	-78.3875
Forest	37.6807	-78.6168	Forest	36.6518	-78.4281
Forest	38.2090	-78.5952	Forest	37.8163	-78.3715
Forest	38.0409	-78.5942	Forest	36.7241	-78.4092
Forest	38.1049	-78.5777	Forest	37.8163	-78.3715
Forest	37.4796	-78.5950	Forest	38.1303	-78.3548
Forest	36.9086	-78.6077	Forest	37.1886	-78.3846

Reference	Y	X	Reference	Y	X
Forest	37.1886	-78.3846	Forest	37.5353	-78.2113
Forest	36.8373	-78.3775	Forest	37.5353	-78.2113
Forest	36.7416	-78.3666	Forest	38.1581	-78.1429
Forest	36.7416	-78.3666	Forest	36.7152	-78.1936
Forest	37.0692	-78.3500	Forest	37.9001	-78.1488
Forest	37.9697	-78.3148	Forest	37.8599	-78.1439
Forest	36.8194	-78.3542	Forest	36.7758	-78.1847
Forest	36.9153	-78.3486	Forest	37.9261	-78.1400
Forest	37.9851	-78.3067	Forest	36.9864	-78.1739
Forest	36.8898	-78.3444	Forest	36.9864	-78.1739
Forest	38.0510	-78.3006	Forest	38.0967	-78.1193
Forest	36.7424	-78.3424	Forest	38.0691	-78.1190
Forest	38.0857	-78.2832	Forest	37.9786	-78.1215
Forest	37.5533	-78.2993	Forest	38.1495	-78.1128
Forest	37.0868	-78.3156	Forest	37.1397	-78.1405
Forest	37.3060	-78.3041	Forest	38.1573	-78.0998
Forest	38.1894	-78.2674	Forest	38.1573	-78.0998
Forest	38.1894	-78.2674	Forest	36.8031	-78.1480
Forest	38.1407	-78.2671	Forest	36.7557	-78.1447
Forest	37.0865	-78.3028	Forest	38.0932	-78.0791
Forest	37.0865	-78.3028	Forest	37.9938	-78.0810
Forest	37.7889	-78.2710	Forest	37.3889	-78.1029
Forest	37.0828	-78.2955	Forest	36.6572	-78.1306
Forest	37.3081	-78.2874	Forest	37.3488	-78.0916
Forest	37.0828	-78.2955	Forest	36.6762	-78.1118
Forest	36.7559	-78.3053	Forest	37.1411	-78.0878
Forest	38.0976	-78.2499	Forest	37.1411	-78.0878
Forest	37.8427	-78.2478	Forest	37.3515	-78.0780
Forest	37.0645	-78.2756	Forest	37.3515	-78.0780
Forest	37.8148	-78.2482	Forest	37.3725	-78.0633
Forest	38.0646	-78.2361	Forest	38.1663	-78.0197
Forest	37.6707	-78.2464	Forest	36.5875	-78.0785
Forest	37.5124	-78.2492	Forest	38.0819	-78.0146
Forest	37.4548	-78.2513	Forest	37.4000	-78.0388
Forest	38.1002	-78.2232	Forest	37.4000	-78.0388
Forest	37.7164	-78.2342	Forest	37.8962	-78.0170
Forest	37.7164	-78.2342	Forest	36.8803	-78.0563
Forest	37.5989	-78.2375	Forest	37.2428	-78.0352
Forest	36.9089	-78.2579	Forest	37.6408	-78.0177
Forest	36.9747	-78.2521	Forest	37.9732	-78.0026
Forest	37.1331	-78.2376	Forest	37.1649	-78.0321
Forest	37.3613	-78.2279	Forest	37.6301	-78.0086
Forest	37.0581	-78.2340	Forest	38.0694	-77.9898

Reference	Y	X	Reference	Y	X
Forest	38.0612	-77.9864	Forest	37.9593	-78.6652
Forest	37.3570	-78.0053	Forest	36.6259	-79.2649
Forest	36.7918	-78.0197	Forest	37.5331	-78.2559
Forest	37.8633	-77.9634	Forest	37.2428	-79.0649
Forest	37.5171	-77.9677	Forest	37.7435	-80.0587
Forest	37.9622	-77.9436	Forest	37.6585	-78.1095
Forest	37.8577	-77.9469	Forest	38.2713	-78.4724
Forest	37.6903	-77.9456	Forest	38.1284	-78.5034
Forest	37.8595	-77.9319	Forest	37.8133	-79.4307
Forest	37.2568	-77.9558	Forest	36.6507	-78.2926
Forest	37.3777	-77.9503	Forest	37.2196	-79.3572
Forest	38.1042	-77.8666	Forest	37.6993	-78.0443
Forest	37.2225	-77.8977	Forest	37.5781	-80.1461
Forest	37.9826	-77.8656	Forest	38.2570	-79.3948
Forest	37.6566	-77.8743	Forest	37.8018	-78.1315
Forest	37.9603	-77.8498	Forest	38.1176	-78.4018
Forest	37.8276	-77.8524	Forest	36.5267	-78.4292
Forest	37.7298	-77.8549	Forest	37.6217	-79.1078
Forest	37.8869	-77.8461	Forest	38.0863	-79.5936
Forest	38.0810	-77.8371	Forest	37.9193	-78.5879
Forest	37.5584	-77.8509	Forest	37.8549	-77.5526
Forest	37.9448	-77.8167	Forest	37.9379	-79.0301
Forest	37.3872	-77.8293	Forest	38.0588	-79.6054
Forest	37.3872	-77.8293	Forest	38.2106	-79.2482
Forest	37.9841	-77.8024	Forest	38.0114	-79.5700
Forest	38.1517	-77.7940	Forest	37.7561	-79.9533
Forest	37.8886	-77.7980	Forest	37.1405	-80.1740
Forest	37.7258	-77.7737	Forest	37.8160	-80.1757
Forest	37.6427	-77.7623	Forest	37.3759	-80.0101
Forest	37.6427	-77.7623	Forest	38.2287	-79.7334
Forest	37.9001	-77.7255	Forest	37.1496	-78.6504
Forest	38.0568	-77.7018	Forest	37.7103	-80.0697
Forest	37.9566	-77.6578	Forest	37.7861	-77.5647
Forest	38.0673	-77.6357	Forest	37.8508	-78.9062
Forest	38.0627	-79.9517	Forest	37.1227	-79.8801
Forest	37.5636	-78.7526	Forest	37.0981	-79.0314
Forest	37.6260	-77.7240	Forest	38.0500	-77.5804
Forest	37.4047	-77.5551	Forest	37.5960	-78.8852
Forest	36.8235	-77.6745	Forest	38.1300	-79.3788
Forest	36.6245	-79.5736	Forest	37.6298	-78.4566
Forest	37.8574	-78.9412	Forest	38.3161	-78.4561
Forest	37.3475	-78.1485	Forest	37.4769	-78.2216
Forest	37.4462	-80.1472	Forest	36.5101	-79.2287

Reference	Y	X	Reference	Y	X
Forest	36.9541	-79.1204	Forest	37.0796	-80.1308
Forest	37.5407	-80.0939	Forest	37.0162	-78.0443
Forest	36.8865	-78.7067	Forest	38.1949	-78.3083
Forest	37.7655	-79.0541	Forest	37.6716	-77.6081
Forest	37.3639	-79.7762	Forest	38.4486	-80.1263
Forest	36.5804	-79.2066	Forest	36.5811	-78.9474
Forest	37.1891	-78.2637	Forest	38.3898	-79.2652
Forest	37.7617	-78.7756	Forest	37.2307	-79.6329
Forest	38.0323	-79.1721	Forest	38.1259	-80.1062
Forest	36.7578	-78.8957	Forest	37.3062	-79.2281
Forest	37.7377	-79.5249	Forest	38.3832	-79.8183
Forest	38.2517	-79.9267	Forest	38.0693	-79.4499
Forest	38.1606	-79.8705	Forest	37.2390	-77.9603
Forest	37.7177	-79.1904	Forest	37.9313	-78.8876
Forest	37.5682	-77.9795	Forest	36.8654	-78.0791
Forest	37.8936	-78.6529	Forest	38.1170	-80.1474
Forest	37.2107	-77.9191	Forest	36.6934	-78.9226
Forest	37.2593	-78.2608	Forest	38.0767	-79.5161
Forest	37.9856	-79.9836	Forest	38.2408	-79.8532
Forest	37.7670	-78.2132	Forest	37.0522	-77.9687
Forest	37.8150	-78.8237	Forest	37.1047	-79.2051
Forest	36.8406	-78.1476	Forest	37.5883	-79.3281
Forest	37.0446	-80.2337	Forest	36.8670	-79.1383
Forest	37.8559	-80.2353	Forest	37.1974	-79.6805
Forest	38.0425	-77.5992	Forest	36.8809	-78.9024
Forest	36.5004	-78.9603	Forest	37.7150	-77.7170
Forest	37.8188	-78.6270	Forest	37.9490	-78.7594
Forest	37.0448	-78.2071	Forest	36.8702	-79.7296
Forest	38.2231	-77.6957	Forest	37.0697	-77.8415
Forest	37.1749	-79.5569	Forest	37.1892	-80.1048
Forest	37.9256	-77.7571	Forest	37.8495	-78.4293
Forest	38.3867	-79.9615	Forest	37.6541	-77.7316
Forest	37.3374	-77.5826	Forest	36.9932	-78.5386
Forest	38.3326	-78.5348	Forest	37.0766	-78.4280
Forest	37.7035	-77.8213	Forest	37.4021	-78.8490
Forest	37.0056	-79.6195	Forest	38.0698	-79.4232
Forest	37.5347	-78.2198	Forest	37.8637	-80.1145
Forest	36.7972	-79.7321	Forest	37.3259	-77.4954
Forest	37.7902	-79.3607	Forest	38.4447	-78.5021
Forest	38.3352	-77.6188	Forest	38.2140	-78.5889
Forest	37.5139	-80.1244	Forest	38.3554	-78.9752
Forest	38.4325	-77.8016	Forest	37.0055	-80.0204
Forest	37.1480	-79.5932	Forest	38.1285	-80.0555

Reference	Y	X	Reference	Y	X
Forest	37.9865	-80.2439	Forest	38.0349	-78.2718
Forest	37.4739	-79.6893	Forest	37.3884	-80.2492
Forest	38.2909	-77.6494	Forest	37.2257	-77.8036
Forest	37.5714	-79.0071	Forest	36.7236	-78.2406
Forest	37.6171	-79.2269	Forest	38.3834	-79.1314
Forest	37.0388	-77.7406	Forest	38.1916	-77.6550
Forest	37.7543	-78.5555	Forest	36.9433	-79.6384
Forest	36.5564	-79.8527	Forest	37.8609	-78.9274
Forest	38.1597	-79.3405	Forest	38.0416	-78.0374
Forest	37.7592	-78.5033	Forest	37.2244	-79.0494
Forest	37.1530	-79.2570	Forest	37.6295	-78.0073
Forest	37.7842	-78.9292	Forest	38.0527	-78.9036
Forest	37.1699	-77.5972	Forest	37.3508	-78.0380
Forest	36.9750	-80.1738	Forest	37.2926	-79.3201
Forest	36.8832	-77.7641	Forest	37.4946	-78.8205
Forest	37.0174	-79.5484	Forest	37.5280	-79.0983
Forest	37.9933	-78.6070	Forest	37.1274	-80.0857
Forest	36.5940	-80.2194	Forest	36.6872	-80.2071
Forest	37.2099	-79.4981	Forest	38.2274	-78.6347
Forest	38.3201	-80.1944	Forest	36.7467	-78.0436
Forest	36.7129	-78.9405	Forest	38.2675	-79.8006
Forest	37.8812	-79.5610	Forest	38.2044	-79.1778
Forest	36.7815	-80.1560	Forest	38.1520	-78.6090
Forest	37.0439	-78.2969	Forest	38.2147	-80.1925
Forest	37.9067	-79.7038	Forest	38.2089	-78.4119
Forest	38.3584	-80.2249	Forest	38.3854	-79.2223
Forest	37.4801	-78.5774	Forest	38.0188	-79.9397
Forest	37.9796	-78.5334	Forest	37.0177	-78.5223
Forest	38.1464	-77.6053	Forest	37.1243	-79.5531
Forest	37.2729	-78.2508	Forest	38.3342	-79.9626
Forest	37.8486	-79.1634	Forest	37.6352	-77.7443
Forest	38.4553	-79.2137	Forest	38.3381	-77.6911
Forest	37.4253	-79.4524	Forest	38.1830	-77.7317
Forest	37.1581	-78.3256	Forest	36.4545	-77.5883
Forest	37.2258	-78.3076	Forest	37.5575	-80.0295
Forest	36.8381	-78.4521	Forest	36.5399	-79.1975
Forest	36.5842	-80.0566	Forest	38.1278	-80.1887
Forest	38.3728	-80.1451	Forest	38.4653	-79.3840
Forest	38.4474	-79.0905	Forest	36.9926	-78.6819
Forest	38.0844	-77.6845	Forest	36.6703	-78.7101
Forest	38.2775	-79.3484	Forest	37.5585	-78.9182
Forest	37.1172	-78.9442	Forest	37.0849	-78.2924
Forest	38.4135	-80.2480	Forest	36.8333	-80.2587

Reference	Y	X	Reference	Y	X
Forest	36.7806	-78.1028	Forest	37.9844	-78.3471
Forest	38.4530	-80.1084	Forest	38.3081	-79.6751
Forest	36.9284	-78.8213	Forest	37.1240	-77.5500
Forest	37.4124	-79.3771	Forest	37.8000	-79.6706
Forest	37.0083	-78.0089	Forest	37.1231	-79.7362
Forest	37.1445	-78.3358	Forest	36.7645	-79.8947
Forest	37.8367	-77.6237	Forest	37.0099	-79.4670
Forest	38.1580	-79.9103	Forest	38.0166	-80.1407
Forest	36.7572	-79.6569	Forest	36.6451	-80.1360
Forest	38.3773	-77.4349	Forest	37.4863	-77.9157
Forest	37.9569	-80.0751	Forest	36.7489	-79.4413
Forest	37.0529	-79.1814	Forest	36.4979	-78.4868
Forest	37.4731	-77.5208	Forest	38.4778	-80.1720
Forest	36.9921	-78.3745	Forest	36.9924	-79.4508
Forest	36.8328	-80.1329	Forest	36.9818	-78.2169
Forest	37.8678	-77.7382	Forest	37.5837	-79.9710
Forest	37.0051	-78.8322	Forest	38.2472	-77.6795
Forest	37.2803	-80.2544	Forest	36.8408	-79.8657
Forest	37.8158	-80.1127	Forest	37.9253	-77.4746
Forest	37.7740	-77.6146	Forest	37.7997	-77.9326
Forest	38.3330	-79.3575	Forest	37.7110	-78.5784
Forest	38.2400	-78.7823	Forest	37.6755	-80.1160
Forest	37.2415	-78.2249	Forest	36.7385	-77.8001
Forest	36.8647	-78.9294	Forest	37.8553	-79.6808
Forest	37.8991	-80.1898	Forest	38.0058	-79.6289
Forest	36.6386	-78.5040	Forest	38.3736	-80.0132
Forest	37.0447	-78.6399	Forest	38.1516	-78.8826
Forest	37.9239	-77.8244	Forest	37.5436	-78.6001
Forest	38.1420	-79.2361	Forest	37.4346	-77.5151
Forest	37.2948	-79.1194	Forest	37.9539	-80.0352
Forest	38.0204	-78.6776	Forest	38.4341	-77.4287
Forest	37.9754	-78.4020	Forest	37.7805	-80.1291
Forest	38.1197	-79.5440	Forest	36.5405	-79.7746
Forest	38.0414	-78.5668	Forest	38.1293	-77.4388
Forest	37.7084	-78.2062	Forest	36.6854	-79.4237
Forest	36.9833	-80.0523	Forest	36.8154	-77.5078
Forest	38.1709	-78.6101	Forest	37.3285	-79.3508
Forest	37.9621	-80.2291	Forest	37.4638	-79.6843
Forest	37.4072	-77.9718	Forest	37.3313	-78.7352
Forest	37.8859	-77.9922	Forest	37.7387	-78.7633
Forest	37.6313	-80.0996	Forest	38.1051	-78.8124
Forest	37.9664	-78.4105	Forest	37.4531	-79.6208
Forest	37.6311	-79.4778	Forest	38.2010	-80.0679

Reference	Y	X	Reference	Y	X
Forest	36.8585	-78.3108	Fringe	37.5155	-79.3039
Forest	37.5150	-78.6601	Fringe	38.0745	-79.1724
Forest	36.7397	-77.5236	Fringe	38.2385	-78.4921
Forest	38.4751	-79.2198	Fringe	37.7423	-78.4494
Forest	37.5296	-79.0161	Fringe	36.9193	-78.4558
Forest	36.8225	-77.5747	Fringe	37.5171	-77.9677
Forest	37.2065	-78.5229	Fringe	36.9826	-79.5767
Forest	37.5322	-79.3402	Fringe	37.6587	-78.7382
Forest	36.8999	-80.1779	Fringe	37.3357	-79.4458
Forest	38.2665	-77.7019	Fringe	37.0477	-79.4858
Forest	37.3047	-78.3884	Fringe	36.5809	-78.1864
Forest	38.2507	-80.1246	Fringe	37.2132	-78.3240
Forest	37.3670	-78.0089	Fringe	36.9468	-79.1233
Forest	38.0265	-79.8398	Fringe	37.3236	-78.5672
Forest	37.5047	-78.3502	Fringe	36.9022	-78.5291
Forest	37.5111	-77.9241	Fringe	37.4221	-78.4416
Forest	37.9150	-80.0057	Fringe	38.1088	-78.3576
Forest	36.5965	-80.2201	Fringe	37.2791	-78.2861
Forest	37.3735	-77.5792	Fringe	37.7618	-77.7098
Forest	38.0590	-78.6630	Fringe	36.7583	-78.1520
Forest	38.2463	-79.4876	Fringe	38.2028	-78.8301
Forest	38.2987	-79.5847	Fringe	37.3526	-78.3573
Forest	38.2582	-80.1577	Fringe	38.2959	-79.1003
Forest	37.1955	-79.0036	Fringe	37.6903	-77.9456
Forest	36.7361	-79.6804	Fringe	36.8597	-78.9087
Forest	37.6057	-77.7327	Fringe	37.9093	-78.8643
Forest	37.3433	-78.5503	Fringe	37.2883	-79.7280
Forest	37.3792	-79.8708	Fringe	37.0448	-79.7463
Forest	37.9622	-77.9436	Fringe	36.7704	-79.0335
Forest	37.3153	-78.8917	Fringe	37.1710	-79.0708
Forest	38.2663	-77.8209	Fringe	36.8136	-77.8276
Fringe	37.2764	-79.7282	Fringe	36.6880	-79.3179
Fringe	36.7394	-78.9116	Fringe	37.7089	-78.5958
Fringe	37.1427	-78.0327	Fringe	36.9654	-79.6087
Fringe	37.4757	-77.8710	Fringe	37.0224	-79.6225
Fringe	37.7060	-79.5378	Fringe	38.0866	-78.6628
Fringe	37.7738	-79.3709	Fringe	36.9848	-79.8025
Fringe	37.4034	-79.1133	Fringe	38.1581	-78.2247
Fringe	37.4262	-79.4589	Fringe	37.5398	-77.6001
Fringe	37.4253	-79.7189	Fringe	36.6136	-79.9847
Fringe	37.1235	-79.6926	Fringe	37.5825	-77.8536
Fringe	36.8758	-79.4283	Fringe	38.0869	-79.3681
Fringe	37.2569	-79.3933	Fringe	38.3753	-78.6755

Reference	Y	X	Reference	Y	X
Fringe	38.2443	-79.0701	House Forested	37.8550	-79.5764
Fringe	37.0553	-80.0923	House Forested	37.7477	-79.5710
Fringe	37.8618	-77.5196	House Forested	37.0586	-79.5793
Fringe	36.9866	-79.0758	House Forested	37.4294	-79.5478
Fringe	36.9662	-79.2030	House Forested	38.0603	-79.5268
Fringe	37.7530	-79.4691	House Forested	37.0717	-79.5341
Fringe	36.7059	-78.2346	House Forested	37.4613	-79.5179
Fringe	37.6854	-77.5132	House Forested	37.8262	-79.4933
Fringe	38.1312	-78.5187	House Forested	37.7534	-79.4857
Fringe	37.2791	-77.9945	House Forested	37.6873	-79.4772
Fringe	37.7016	-78.6600	House Forested	37.1042	-79.4767
Fringe	36.4821	-77.6460	House Forested	37.1071	-79.4682
House Forested	37.3410	-78.8964	House Forested	37.1639	-79.4462
House Forested	37.8352	-78.9411	House Forested	37.8918	-79.4155
House Forested	37.0645	-78.2756	House Forested	37.5243	-79.4071
House Forested	37.9215	-77.7856	House Forested	37.0762	-79.4051
House Forested	37.2479	-79.7432	House Forested	37.0688	-79.4048
House Forested	36.9006	-80.0520	House Forested	37.4615	-79.3949
House Forested	36.8657	-79.9698	House Forested	37.3577	-79.3922
House Forested	37.1267	-79.9570	House Forested	37.4439	-79.3865
House Forested	36.9611	-79.9302	House Forested	37.3779	-79.3827
House Forested	37.1587	-79.8994	House Forested	37.2007	-79.3570
House Forested	36.9657	-79.8831	House Forested	37.2144	-79.3377
House Forested	36.9527	-79.8680	House Forested	37.7359	-79.2925
House Forested	36.9919	-79.8643	House Forested	37.4687	-79.2760
House Forested	37.0442	-79.7973	House Forested	37.4559	-79.2305
House Forested	37.3559	-79.7653	House Forested	37.3248	-79.2207
House Forested	37.0272	-79.7527	House Forested	37.2811	-79.2076
House Forested	37.0343	-79.7350	House Forested	37.9924	-79.1883
House Forested	37.0937	-79.6948	House Forested	37.7127	-79.1756
House Forested	37.0641	-79.6952	House Forested	38.0417	-79.1497
House Forested	37.0288	-79.6942	House Forested	38.3057	-79.1246
House Forested	37.5178	-79.6779	House Forested	37.6092	-79.1375
House Forested	36.9947	-79.6855	House Forested	37.9788	-79.1226
House Forested	37.0918	-79.6798	House Forested	37.9818	-79.1209
House Forested	37.1634	-79.6773	House Forested	37.1766	-79.1400
House Forested	37.1106	-79.6780	House Forested	37.6705	-79.0967
House Forested	37.0328	-79.6685	House Forested	36.9972	-79.1002
House Forested	37.6515	-79.6471	House Forested	37.4352	-79.0785
House Forested	37.1317	-79.6373	House Forested	36.9491	-79.0839
House Forested	37.1065	-79.6280	House Forested	37.4621	-79.0681
House Forested	37.5639	-79.6042	House Forested	37.6292	-79.0577
House Forested	37.8907	-79.5767	House Forested	37.1704	-79.0546

Reference	Y	X	Reference	Y	X
House Forested	37.7288	-79.0093	House Forested	37.6992	-78.6645
House Forested	37.6032	-78.9941	House Forested	37.9636	-78.6539
House Forested	37.6306	-78.9625	House Forested	37.9636	-78.6539
House Forested	38.1806	-78.9460	House Forested	38.1082	-78.6430
House Forested	38.1403	-78.9371	House Forested	38.0222	-78.6436
House Forested	38.1354	-78.9366	House Forested	38.1787	-78.6326
House Forested	38.3073	-78.8949	House Forested	38.2440	-78.6276
House Forested	37.8699	-78.9072	House Forested	38.0462	-78.6298
House Forested	37.8330	-78.9001	House Forested	38.0667	-78.6257
House Forested	37.2070	-78.9173	House Forested	38.0919	-78.6248
House Forested	37.9123	-78.8925	House Forested	37.7835	-78.6310
House Forested	37.1970	-78.9119	House Forested	38.1529	-78.6160
House Forested	37.6567	-78.8969	House Forested	37.8793	-78.6102
House Forested	37.6513	-78.8930	House Forested	38.0032	-78.5992
House Forested	36.7546	-78.9158	House Forested	38.0944	-78.5918
House Forested	37.9227	-78.8752	House Forested	38.1008	-78.5797
House Forested	37.9234	-78.8731	House Forested	38.0842	-78.5797
House Forested	37.8659	-78.8690	House Forested	37.9457	-78.5702
House Forested	37.8179	-78.8703	House Forested	37.9590	-78.5591
House Forested	37.8858	-78.8671	House Forested	37.3282	-78.5734
House Forested	36.7658	-78.8968	House Forested	38.0070	-78.5502
House Forested	38.1573	-78.8464	House Forested	38.0684	-78.5442
House Forested	37.9048	-78.8488	House Forested	37.8395	-78.5494
House Forested	37.8567	-78.8451	House Forested	38.2220	-78.5319
House Forested	37.3363	-78.8538	House Forested	36.6118	-78.5835
House Forested	38.1506	-78.8158	House Forested	37.9870	-78.5370
House Forested	37.8317	-78.8169	House Forested	37.9891	-78.5355
House Forested	38.2853	-78.7962	House Forested	38.1153	-78.5253
House Forested	36.7346	-78.8375	House Forested	38.1936	-78.5156
House Forested	37.2620	-78.8168	House Forested	37.1408	-78.5457
House Forested	37.9936	-78.7943	House Forested	37.1976	-78.5418
House Forested	37.8138	-78.7814	House Forested	37.8561	-78.5120
House Forested	38.0554	-78.7535	House Forested	38.1447	-78.4975
House Forested	37.8084	-78.7413	House Forested	37.7964	-78.5090
House Forested	36.7618	-78.7685	House Forested	37.2723	-78.5242
House Forested	38.1281	-78.7039	House Forested	38.1811	-78.4806
House Forested	38.0935	-78.6949	House Forested	38.1811	-78.4779
House Forested	38.1303	-78.6868	House Forested	38.1046	-78.4786
House Forested	37.8161	-78.6923	House Forested	38.1525	-78.4767
House Forested	37.8118	-78.6870	House Forested	37.8948	-78.4846
House Forested	38.0589	-78.6693	House Forested	38.1539	-78.4755
House Forested	38.2083	-78.6576	House Forested	38.1920	-78.4740
House Forested	38.0781	-78.6572	House Forested	38.1856	-78.4717

Reference	Y	X	Reference	Y	X
House Forested	38.2521	-78.4625	House Forested	37.4630	-78.3072
House Forested	38.1463	-78.4639	House Forested	37.8913	-78.2773
House Forested	37.7895	-78.4459	House Forested	37.9574	-78.2725
House Forested	38.0940	-78.4295	House Forested	37.3040	-78.2862
House Forested	38.0834	-78.4283	House Forested	37.9076	-78.2625
House Forested	38.1766	-78.4144	House Forested	38.0049	-78.2517
House Forested	37.1717	-78.4427	House Forested	37.8864	-78.2491
House Forested	37.1546	-78.4431	House Forested	38.0089	-78.2439
House Forested	37.8502	-78.4129	House Forested	37.8942	-78.2420
House Forested	37.2353	-78.4340	House Forested	37.9957	-78.2355
House Forested	37.9430	-78.4007	House Forested	38.0576	-78.2269
House Forested	38.0738	-78.3942	House Forested	38.0815	-78.2240
House Forested	38.1898	-78.3898	House Forested	37.5313	-78.2425
House Forested	38.1611	-78.3854	House Forested	37.8573	-78.2280
House Forested	38.1682	-78.3745	House Forested	37.7175	-78.2293
House Forested	38.1422	-78.3712	House Forested	37.9299	-78.2202
House Forested	38.1742	-78.3700	House Forested	38.1129	-78.2065
House Forested	38.1588	-78.3685	House Forested	37.7388	-78.2195
House Forested	38.1413	-78.3688	House Forested	38.0707	-78.1902
House Forested	37.2255	-78.4008	House Forested	37.9704	-78.1629
House Forested	38.1291	-78.3669	House Forested	38.1079	-78.1506
House Forested	38.2190	-78.3619	House Forested	38.1072	-78.1433
House Forested	36.6712	-78.4129	House Forested	38.0800	-78.1431
House Forested	37.9456	-78.3687	House Forested	37.8827	-78.1455
House Forested	38.2344	-78.3489	House Forested	37.9436	-78.1273
House Forested	37.8432	-78.3617	House Forested	38.0076	-78.1157
House Forested	37.8122	-78.3612	House Forested	37.9533	-78.1099
House Forested	37.9082	-78.3569	House Forested	37.9728	-78.1080
House Forested	38.1742	-78.3441	House Forested	37.9537	-78.1076
House Forested	37.9013	-78.3433	House Forested	37.9239	-78.1060
House Forested	37.9547	-78.3398	House Forested	37.9579	-78.1044
House Forested	37.8891	-78.3402	House Forested	38.1014	-78.0965
House Forested	37.8875	-78.3401	House Forested	37.7835	-78.1050
House Forested	37.9910	-78.3318	House Forested	37.9581	-78.0977
House Forested	37.9657	-78.3298	House Forested	37.8818	-78.0976
House Forested	37.8947	-78.3299	House Forested	37.9596	-78.0941
House Forested	37.9253	-78.3228	House Forested	37.9942	-78.0811
House Forested	37.8651	-78.3215	House Forested	37.7987	-78.0851
House Forested	38.0422	-78.3091	House Forested	38.0311	-78.0740
House Forested	36.6420	-78.3539	House Forested	37.9992	-78.0726
House Forested	38.0440	-78.3019	House Forested	38.1233	-78.0599
House Forested	37.7884	-78.3075	House Forested	37.9263	-78.0614
House Forested	36.6856	-78.3423	House Forested	37.7210	-78.0657

Reference	Y	X
House Forested	37.7210	-78.0657
House Forested	38.1219	-78.0459
House Forested	37.8677	-78.0509
House Forested	38.0863	-78.0412
House Forested	37.9250	-78.0409
House Forested	37.7717	-78.0452
House Forested	37.6277	-78.0412
House Forested	37.8665	-78.0309
House Forested	38.0021	-78.0215
House Forested	38.0005	-78.0176
House Forested	37.8673	-78.0173
House Forested	37.9902	-78.0077
House Forested	37.9883	-78.0076
House Forested	37.8996	-78.0021
House Forested	37.9129	-78.9004
House Forested	36.5412	-79.7605
House Forested	36.9414	-80.0508
House Forested	37.3488	-79.9803
House Forested	37.2254	-77.5251
House Forested	37.3073	-78.0394
House Forested	37.7552	-79.3761
House Forested	38.1492	-78.8443
House Forested	37.5168	-78.0203
House Not Forested	37.4985	-79.1255
House Not Forested	37.1337	-79.5695
House Not Forested	38.0452	-79.8713
House Not Forested	37.5286	-77.5864
House Not Forested	36.6833	-79.8566
House Not Forested	36.5837	-78.2590
House Not Forested	37.1707	-80.2453
House Not Forested	37.9080	-77.8466
House Not Forested	38.3980	-78.3210
House Not Forested	37.6027	-77.6272
House Not Forested	38.2740	-78.8231
House Not Forested	37.8364	-79.2857
House Not Forested	37.0883	-77.9963
House Not Forested	37.8407	-79.9767
House Not Forested	36.9242	-79.0137
House Not Forested	36.5608	-78.4335
House Not Forested	36.6460	-78.1938
House Not Forested	37.3320	-79.8827
House Not Forested	38.0770	-78.9292
House Not Forested	38.0374	-77.7625
House Not Forested	38.3074	-80.0223
Road	36.5206	-79.8928
Road	36.9461	-78.8885
Road	36.8535	-78.6077
Road	36.5667	-78.2714
Road	38.1468	-79.9817
Road	37.3715	-77.9193
Road	36.5115	-77.9140
Road	37.3192	-77.4896
Road	36.9564	-77.8115
Road	37.2776	-79.8774
Road	37.3576	-79.9555
water	36.6361	-78.3880
water	36.4840	-78.3453
water	38.0440	-77.7765
water	38.0437	-77.7461
water	38.0255	-77.7336
water	36.5159	-77.9409
water	38.0341	-77.6003
water	37.9357	-77.4421
water	36.8943	-78.5923
water	36.8941	-78.1588
water	37.7727	-79.3894
water	37.1890	-79.7510
water	37.7649	-78.5456
water	37.9975	-79.9434

Reference	X	Y	Year of Disturbance	Recovery Maximum (High) NDVI Value	Slope
Disturbed	-77.264	36.955	1	0.854728162	0.03052827
Disturbed	-78.626	37.250	1	0.914398491	0.013719273
Disturbed	-77.274	37.962	1	0.901442289	0.017779835
Disturbed	-79.059	37.255	1	0.888226807	0.009910913
Disturbed	-77.523	37.041	2	0.906398714	0.026740739
Disturbed	-76.883	37.615	2	0.875626862	0.027304176
Disturbed	-80.865	36.757	2	0.909799576	0.011018757
Disturbed	-78.751	37.228	2	0.870619953	0.015172685
Disturbed	-79.039	37.552	2	0.855345905	0.020210819
Disturbed	-77.714	37.947	2	0.901161194	0.013253736
Disturbed	-78.072	36.723	2	0.892725289	0.009245188
Disturbed	-78.428	37.022	2	0.891373813	0.014337191
Disturbed	-77.876	37.858	2	0.907362282	0.010958884
Disturbed	-78.703	36.979	2	0.911496162	0.00855791
Disturbed	-76.742	37.625	3	0.866056085	0.024062065
Disturbed	-78.738	37.344	3	0.885514021	0.020150755
Disturbed	-77.319	36.893	3	0.917222202	0.022527592
Disturbed	-78.501	37.612	3	0.881987572	0.026746068
Disturbed	-76.848	37.903	3	0.884836853	0.01836827
Disturbed	-78.475	37.117	3	0.88892138	0.008244857
Disturbed	-77.715	37.955	3	0.905165136	0.023675159
Disturbed	-78.104	38.078	3	0.891089082	0.01905225
Disturbed	-77.532	37.817	3	0.901916862	0.015088398
Disturbed	-77.748	37.343	3	0.907443523	0.016438665
Disturbed	-78.353	37.098	3	0.881549001	0.002908172
Disturbed	-78.647	36.838	3	0.887316585	0.011621986
Disturbed	-78.482	37.700	3	0.902130485	0.016091736
Disturbed	-79.381	36.985	3	0.905714929	0.008257682
Disturbed	-78.065	36.718	3	0.904477596	0.010233155
Disturbed	-77.023	37.393	3	0.918378234	0.008861001
Disturbed	-79.589	37.290	3	0.877337992	0.010438669
Disturbed	-77.711	37.146	3	0.886469662	0.013086667
Disturbed	-76.846	37.599	3	0.981024683	0.009519091
Disturbed	-78.320	37.281	3	0.893681526	0.008811911
Disturbed	-77.854	38.018	3	0.877631187	0.011380885
Disturbed	-78.684	36.741	3	0.894713342	0.009371123
Disturbed	-77.573	37.220	3	0.90370369	0.011599578
Disturbed	-77.125	37.068	3	0.921725214	0.007043131
Disturbed	-79.694	37.112	3	0.863124013	0.005384151
Disturbed	-77.719	36.591	3	0.880147696	0.00736756
Disturbed	-77.688	37.279	4	0.905769229	0.019591095
Disturbed	-78.911	37.145	4	0.855049312	0.014231324
Disturbed	-78.760	37.291	4	0.885276377	0.021232462

Disturbed	-78.803	36.752	4	0.87110436	0.020081341
Disturbed	-79.183	36.938	4	0.854278088	0.019909574
Disturbed	-79.750	36.579	4	0.909601867	0.01511978
Disturbed	-78.532	37.666	4	0.905111253	0.013911032
Disturbed	-78.683	37.292	4	0.892627418	0.01586544
Disturbed	-79.410	36.848	4	0.884615362	0.020180991
Disturbed	-78.913	36.821	4	0.894095421	0.016301071
Disturbed	-78.443	37.178	4	0.92165035	0.011918376
Disturbed	-77.109	37.211	4	0.855644643	0.013203597
Disturbed	-77.721	36.591	5	0.868258178	0.019997627
Disturbed	-77.617	37.319	5	0.901207864	0.020311603
Disturbed	-78.603	37.307	5	0.896911621	0.022301216
Disturbed	-77.711	37.250	5	0.881275833	0.020130675
Disturbed	-79.427	37.143	5	0.817177296	0.011387227
Disturbed	-78.231	38.055	5	0.853194356	0.01384585
Disturbed	-78.156	37.208	5	0.888386905	0.01491749
Disturbed	-80.129	37.541	5	0.910538316	0.012111166
Disturbed	-77.861	36.906	5	0.892935991	0.015476833
Disturbed	-78.790	38.181	5	0.894702196	0.011763196
Disturbed	-78.727	36.677	6	0.875769436	0.030072464
Disturbed	-79.741	36.723	6	0.859360158	0.031379767
Disturbed	-78.764	37.172	6	0.903984427	0.024226233
Disturbed	-78.641	37.126	6	0.909463167	0.025630688
Disturbed	-79.479	36.779	6	0.863157868	0.036872134
Disturbed	-77.340	36.771	6	0.868927598	0.026220081
Disturbed	-77.403	36.780	6	0.859353781	0.02403616
Disturbed	-78.283	39.422	6	0.90577811	0.017708877
Disturbed	-77.959	36.814	6	0.896280229	0.020227853
Disturbed	-78.431	37.331	6	0.880611062	0.020646159
Disturbed	-78.839	36.664	6	0.883048892	0.010448914
Disturbed	-78.697	37.705	7	0.851554692	0.041388229
Disturbed	-78.740	37.344	7	0.857246876	0.027106203
Disturbed	-76.998	37.122	7	0.821444571	0.024912972
Disturbed	-78.168	37.731	7	0.890423357	0.032196727
Disturbed	-79.368	37.001	7	0.881592572	0.025340363
Disturbed	-78.374	37.942	7	0.847425997	0.019754168
Disturbed	-79.515	36.917	7	0.876555026	0.01017306
Disturbed	-77.870	36.804	7	0.877135873	0.022397321
Disturbed	-76.943	37.142	7	0.875497282	0.019582279
Disturbed	-78.704	36.981	7	0.870062768	0.016970159
Disturbed	-77.015	37.493	7	0.825095057	0.011098282
Disturbed	-78.546	37.390	7	0.906032026	0.018284902
Disturbed	-78.615	37.346	7	0.885927796	0.014453463
Disturbed	-78.076	37.598	7	0.875235081	0.015723394
Disturbed	-78.347	37.337	7	0.908898294	0.016865402
Disturbed	-79.423	37.358	7	0.860941589	0.011606936

Disturbed	-77.072	36.889	7	0.89316839	0.014726914
Disturbed	-77.836	36.648	8	0.904263258	0.045852985
Disturbed	-77.014	37.740	8	0.891938269	0.032932885
Disturbed	-77.484	38.073	8	0.880139768	0.044465788
Disturbed	-77.010	36.983	8	0.813245058	0.031357247
Disturbed	-78.117	37.794	8	0.885254681	0.034851357
Disturbed	-77.056	37.404	8	0.859568894	0.017926916
Disturbed	-78.173	37.464	8	0.846373379	0.025131743
Disturbed	-77.824	36.676	8	0.859925389	0.028332528
Disturbed	-77.783	37.261	8	0.876844108	0.012827981
Disturbed	-76.679	37.976	8	0.902654886	0.023551786
Disturbed	-82.366	36.921	8	0.882187963	0.025439249
Disturbed	-77.317	37.141	8	0.864857972	0.020208834
Disturbed	-77.204	37.984	9	0.866618872	0.042732082
Disturbed	-78.773	37.133	9	0.868682861	0.037603159
Disturbed	-82.049	37.063	9	0.901090622	0.040469494
Disturbed	-76.743	37.626	9	0.833450973	0.036163259
Disturbed	-77.419	36.730	9	0.784362733	0.043927241
Disturbed	-77.760	37.145	9	0.835869908	0.021627136
Disturbed	-79.051	36.711	9	0.892659843	0.025769856
Disturbed	-80.891	36.639	9	0.907435536	0.03905635
Disturbed	-77.074	37.131	10	0.842355192	0.066051818
Disturbed	-77.870	36.764	10	0.894210517	0.067319259
Disturbed	-77.113	37.212	10	0.798710585	0.037547626
Disturbed	-78.714	37.543	10	0.836885035	0.049082316
Disturbed	-78.362	36.629	10	0.845771134	0.037573297
Disturbed	-77.706	37.406	10	0.848272145	0.032840509
Disturbed	-77.519	37.946	10	0.863816321	0.024858788
Disturbed	-77.229	36.772	10	0.870233357	0.026742488
Disturbed	-78.633	37.567	10	0.870304763	0.027735753
Disturbed	-79.099	36.820	11	0.846389413	0.057447374
Disturbed	-77.775	38.128	11	0.879436076	0.057265181
Disturbed	-78.568	37.541	11	0.871551514	0.05371191
Disturbed	-77.743	36.750	11	0.836026609	0.048844434
Disturbed	-76.882	37.800	11	0.868270338	0.047162753
Disturbed	-77.013	37.493	11	0.867295921	0.04391126
Disturbed	-78.887	36.785	11	0.888932049	0.046067622
Disturbed	-77.156	36.749	12	0.756070316	0.076795116
Disturbed	-77.293	37.077	12	0.820459306	0.059554674
Disturbed	-79.125	37.000	12	0.88230437	0.070871845
Disturbed	-79.512	36.749	12	0.801110089	0.058541894
Disturbed	-82.735	36.926	12	0.86119467	0.064613782
Disturbed	-77.271	36.614	12	0.821953773	0.044634577
Disturbed	-78.027	37.814	12	0.829534173	0.048748259
Disturbed	-77.518	37.709	12	0.853672028	0.055196755
Disturbed	-76.659	37.716	12	0.832874835	0.049365547

Disturbed	-76.934	37.115	12	0.852631569	0.053894334
Disturbed	-77.564	36.885	12	0.87714988	0.058915619
Disturbed	-80.550	37.412	12	0.877964556	0.049701225
Disturbed	-76.975	37.984	13	0.859216273	0.094181813
Disturbed	-76.736	36.935	13	0.916728914	0.122759826
Disturbed	-78.583	37.672	13	0.818069279	0.092565231
Disturbed	-78.949	36.648	13	0.815544486	0.090617761
Disturbed	-76.637	36.628	13	0.811949074	0.092014231
Disturbed	-77.815	38.063	13	0.872643173	0.100880831
Disturbed	-77.716	36.674	13	0.729458928	0.05220858
Disturbed	-78.586	37.670	13	0.818947375	0.092312641
Disturbed	-82.016	37.090	13	0.873925507	0.094043069
Disturbed	-79.643	36.691	13	0.858652294	0.097157657
Disturbed	-82.292	36.957	13	0.793855309	0.06950818
Disturbed	-79.704	38.077	13	0.846153855	0.083931193
Disturbed	-77.695	37.253	13	0.874569595	0.089262486
Disturbed	-79.154	36.831	13	0.835003197	0.083556935
Disturbed	-78.095	37.140	13	0.88173455	0.093244858
Disturbed	-76.901	37.645	13	0.831676602	0.070735842
Disturbed	-79.735	36.548	13	0.850760698	0.082503684
Disturbed	-77.235	36.755	14	0.727696776	0.142083734
Disturbed	-77.532	37.002	14	0.753609836	0.143935949
Disturbed	-79.175	36.976	14	0.837877691	0.151016489
Disturbed	-77.255	36.784	14	0.827860177	0.157542735
Disturbed	-78.737	37.565	14	0.870914102	0.169057816
Disturbed	-78.811	37.581	14	0.752136767	0.11653313
Disturbed	-78.418	36.935	14	0.873220026	0.161066175
Disturbed	-79.058	36.939	14	0.86276716	0.150473937
Disturbed	-78.925	36.988	14	0.853905797	0.15397495
Disturbed	-76.861	37.477	14	0.854545474	0.141280681
Disturbed	-78.653	36.796	14	0.820405543	0.128899902
House Forested	-79.576	37.082	1	0.893569827	0.00332199
House Forested	-80.864	36.757	2	0.889282882	0.014890128
House Forested	-77.275	38.735	2	0.821143031	0.014644817
House Forested	-76.414	37.112	2	0.912467599	-0.0012802
House Forested	-76.517	37.073	2	0.845110834	0.006824598
House Forested	-77.151	38.805	3	0.896153867	0.023733532
House Forested	-78.261	37.001	3	0.87330538	0.015016368
House Forested	-77.037	37.698	3	0.840916336	0.010421815
House Forested	-77.759	37.791	3	0.916939914	0.013287248
House Forested	-76.473	37.118	3	0.867944598	0.004879894
House Forested	-77.231	37.433	3	0.915857613	-0.002099762
House Forested	-77.909	37.717	3	0.912241459	0.00645306
House Forested	-77.141	38.790	4	0.89950788	0.016267676
House Forested	-79.882	37.321	4	0.887401938	0.025137192
House Forested	-77.485	38.234	4	0.866878808	0.019312726

House Forested	-77.657	37.211	4	0.787745535	0.005760697
House Forested	-77.466	37.145	4	0.824852705	0.007859153
House Forested	-77.062	37.225	4	0.872941196	0.006233587
House Forested	-77.534	38.364	4	0.875228584	0.019304767
House Forested	-79.867	36.953	4	0.884889185	0.003751626
House Forested	-77.392	39.043	4	0.840830445	0.005164794
House Forested	-77.348	39.048	5	0.642003536	0.009975102
House Forested	-76.080	36.729	5	0.77346617	0.005278455
House Forested	-77.360	39.052	5	0.79894489	0.008073666
House Forested	-77.435	37.678	5	0.872576177	0.021332325
House Forested	-76.783	37.325	5	0.873908281	0.016896451
House Forested	-77.338	37.446	5	0.839506149	0.006788645
House Forested	-76.748	37.329	5	0.882102549	0.012326778
House Forested	-77.534	37.344	5	0.793277323	0.012226355
House Forested	-76.531	37.098	6	0.57734704	0.004367436
House Forested	-77.395	38.885	6	0.844176292	-0.001262447
House Forested	-77.292	37.536	6	0.713708639	0.033214755
House Forested	-77.630	37.702	6	0.702919304	-0.002585598
House Forested	-77.389	37.499	6	0.734513283	0.0174533
House Forested	-77.332	37.633	6	0.875550926	0.013070103
House Forested	-77.503	39.105	6	0.757075489	0.006669409
House Forested	-77.196	37.578	6	0.828915656	0.011534489
House Forested	-79.656	36.980	6	0.799546719	0.005677572
House Forested	-78.165	39.209	6	0.826513886	0.006369695
House Forested	-77.672	38.878	6	0.941756248	0.014152266
House Forested	-79.653	37.065	6	0.865399837	0.007594487
House Forested	-77.487	38.469	6	0.88996315	0.013758946
House Forested	-77.516	38.376	6	0.853330016	0.014292625
House Forested	-77.307	38.577	7	0.544126213	0.009199053
House Forested	-77.511	39.051	7	0.779936969	0.012089623
House Forested	-77.426	38.765	7	0.713149846	0.015731432
House Forested	-77.645	37.274	7	0.799381375	0.021743305
House Forested	-76.658	37.223	7	0.823327601	0.003392801
House Forested	-77.409	38.852	7	0.688575447	0.000126759
House Forested	-77.510	39.091	7	0.751373649	0.000333706
House Forested	-77.521	37.329	7	0.814319432	0.026841149
House Forested	-77.217	38.949	7	0.752411604	0.015303297
House Forested	-77.426	38.443	7	0.90971452	0.022604253
House Forested	-77.615	37.400	7	0.69599998	0.012167496
House Forested	-77.325	38.869	7	0.70476681	0.012203626
House Forested	-78.346	38.995	7	0.745337605	0.013151754
House Forested	-77.679	37.396	7	0.834763944	0.002742718
House Forested	-76.815	37.436	7	0.803743601	0.002847982
House Forested	-77.372	38.671	7	0.885938168	0.011588353
House Forested	-76.751	37.332	7	0.759173155	0.016845025
House Forested	-77.142	37.772	7	0.809029877	0.020481551

House Forested	-76.681	37.242	7	0.757114708	0.009800265
House Forested	-77.328	37.608	7	0.852142274	0.010230612
House Forested	-77.305	38.580	8	0.588568211	0.014942681
House Forested	-77.387	38.619	8	0.6356498	0. 025255159
House Forested	-78.535	38.014	8	0.642043769	0.015838716
House Forested	-77.408	38.858	8	0.67078191	0.016185526
House Forested	-77.513	39.109	8	0.705186963	0.020360555
House Forested	-76.750	37.332	8	0.603462696	0.015230017
House Forested	-77.275	38.668	8	0.679608703	0.006515983
House Forested	-77.125	38.795	8	0.786684811	0.017876102
House Forested	-77.437	38.358	8	0.753615975	0.01182022
House Forested	-76.545	37.172	8	0.640240252	0.01519461
House Forested	-77.733	38.274	8	0.737200141	0.019445762
House Forested	-77.124	38.794	8	0.80787909	0.012745067
House Forested	-77.563	38.267	8	0.581558347	0.005908268
House Forested	-76.730	37.242	8	0.630041718	0.008993741
House Forested	-77.411	38.853	8	0.634204268	0.00734393
House Forested	-77.359	39.044	8	0.727196157	0.014786351
House Forested	-77.554	38.747	8	0.743898571	0.027420688
House Forested	-77.380	39.024	8	0.763128519	0.005433287
House Forested	-77.436	38.356	8	0.665544331	0.010798404
House Forested	-77.428	38.443	8	0.70194751	0.009450223
House Forested	-77.564	38.272	8	0.680470228	0.013553445
House Forested	-77.568	38.764	8	0.705785096	0.019589605
House Forested	-77.328	38.591	8	0.766880214	0.014908743
House Forested	-77.172	38.307	8	0.793902159	0.029422143
House Forested	-77.098	38.703	8	0.748620152	0.020740187
House Forested	-76.800	37.274	8	0.711330056	0.011411688
House Forested	-77.524	38.993	8	0.870282471	0.018187657
House Forested	-77.319	37.212	8	0.798984766	0.013067854
House Forested	-77.320	38.617	8	0.760402679	0.015310064
House Forested	-77.432	38.244	8	0.803046227	0.017349401
House Forested	-77.089	38.792	8	0.822079837	0.005357102
House Forested	-77.616	37.451	8	0.847310603	0.026757531
House Forested	-76.849	37.247	8	0.793340206	0.016666666
House Forested	-77.477	38.773	8	0.761172175	0.00957597
House Forested	-77.501	38.274	8	0.848181367	0.020204794
House Forested	-77.478	38.724	8	0.797890067	0.017550511
House Forested	-77.414	37.707	8	0.786187351	0.009678139
House Forested	-77.752	37.855	8	0.862397254	0.015959572
House Forested	-77.389	38.620	9	0.616991162	0.024835935
House Forested	-76.130	36.770	9	0.565217376	0.01627758
House Forested	-77.320	38.599	9	0.550505042	0.029357832
House Forested	-77.311	38.618	9	0.690249443	0.02458529
House Forested	-76.466	37.158	9	0.654078066	0.022869525
House Forested	-76.468	37.127	9	0.688318074	0.027065761

House Forested	-77.424	38.806	9	0.611711979	0.006304737
House Forested	-77.771	38.715	9	0.68026644	0.026364846
House Forested	-77.589	38.289	9	0.69909209	0.015326898
House Forested	-77.238	38.900	9	0.803105414	0.01336358
House Forested	-81.819	37.178	9	0.90225935	0.022344165
House Forested	-77.363	38.636	10	0.561739147	0.012570572
House Forested	-78.471	38.047	10	0.614983737	0.020980766
House Forested	-77.658	37.492	10	0.725974739	0.017714443
House Forested	-77.208	38.717	10	0.53768456	0.012433928
House Forested	-77.590	37.661	10	0.609120548	0.023063323
House Forested	-77.612	38.769	10	0.575650096	0.02033519
House Forested	-81.269	37.225	10	0.71170181	0.028247653
House Forested	-77.470	39.058	10	0.679219723	0.004241186
House Forested	-77.399	37.558	10	0.724531353	0.00625762
House Forested	-77.307	38.579	10	0.727578163	0.021846503
House Forested	-77.790	38.533	10	0.631423533	0.009196342
House Forested	-77.322	38.290	10	0.732372284	0.019533372
House Forested	-77.593	38.767	10	0.651162803	0.013839223
House Forested	-77.396	37.660	10	0.72525692	0.028150028
House Forested	-77.219	38.893	10	0.777587175	0.012929287
House Forested	-78.189	39.170	10	0.713671744	0.025197165
House Forested	-77.668	37.475	10	0.726373255	0.01910462
House Forested	-77.421	38.699	10	0.776630104	0.024486279
House Forested	-77.297	37.535	11	0.722578824	0.051858734
House Forested	-76.135	36.767	11	0.612742364	0.029857421
House Forested	-77.292	37.227	11	0.589413464	0.028343124
House Forested	-76.814	37.270	11	0.683276832	0.039564181
House Forested	-77.715	37.387	11	0.703153968	0.036125455
House Forested	-77.346	38.698	11	0.743646383	0.032272175
House Forested	-76.814	37.268	11	0.698841691	0.032033667
House Forested	-78.348	38.995	11	0.726696253	0.030789834
House Forested	-77.619	37.681	11	0.659149468	0.024538472
House Forested	-77.693	37.786	11	0.851662397	0.030062206
House Forested	-77.412	38.849	12	0.513912141	0.024718091
House Forested	-77.504	39.234	12	0.708749592	0.069857091
House Forested	-77.613	38.768	12	0.605744123	0.04917736
House Forested	-77.517	38.226	12	0.740494549	0.080685638
House Forested	-76.422	37.213	12	0.628727615	0.047656003
House Forested	-77.463	39.040	12	0.681512833	0.056163535
House Forested	-77.493	39.054	12	0.653315842	0.045037441
House Forested	-77.320	38.295	12	0.636267483	0.037780903
House Forested	-76.781	37.271	12	0.73569876	0.050123464
House Forested	-76.192	36.776	12	0.605546117	0.036414828
House Forested	-77.407	38.443	12	0.739023209	0.047111828
House Forested	-77.754	38.372	12	0.687606096	0.030474422
House Forested	-77.235	38.728	12	0.712105811	0.045464586

House Forested	-80.867	36.759	12	0.857868016	0.062483028
House Forested	-77.244	38.294	12	0.83324337	0.053764429
House Forested	-78.297	39.277	12	0.792955577	0.044499956
House Forested	-78.094	38.928	12	0.807734191	0.035424188
House Forested	-77.454	38.726	13	0.606312275	0.073223978
House Forested	-77.308	37.520	13	0.560168326	0.059914757
House Forested	-77.419	37.268	13	0.570265889	0.056749947
House Forested	-77.373	37.287	13	0.552935302	0.05130152
House Forested	-77.549	38.932	13	0.657294095	0.070392005
House Forested	-77.569	38.738	13	0.617021263	0.054761887
House Forested	-77.633	37.730	13	0.726633191	0.076293238
House Forested	-77.331	37.446	13	0.577818632	0.048224874
House Forested	-77.510	39.093	13	0.754574835	0.086457096
House Forested	-77.259	38.615	13	0.602739751	0.054298669
House Forested	-79.640	37.083	13	0.735205054	0.076899558
House Forested	-77.658	38.836	13	0.716576159	0.072467849
House Forested	-79.676	37.073	13	0.751609921	0.077246308
House Forested	-78.090	39.166	13	0.695652187	0.055776373
House Forested	-76.572	37.448	13	0.794685304	0.080627866
House Forested	-77.630	37.590	13	0.799555957	0.07459981
House Forested	-77.481	37.222	13	0.799840748	0.068965621
House Forested	-77.538	38.915	13	0.828482985	0.086278461
House Forested	-77.694	37.641	13	0.847058833	0.084771171
House Forested	-78.331	37.915	13	0.871625066	0.08334858
House Forested	-77.192	37.485	13	0.765217364	0.066820189
House Forested	-77.733	38.268	13	0.794392526	0.067472413
House Forested	-77.369	38.892	13	0.785317719	0.067664556
House Forested	-77.138	37.771	13	0.801385701	0.067070208
House Forested	-77.609	38.837	13	0.841894984	0.074940726
House Forested	-77.891	37.366	13	0.859941244	0.082849383
House Forested	-77.591	37.675	14	0.482638896	0.074915908
House Forested	-77.531	38.331	14	0.64542079	0.116987936
House Forested	-77.703	38.735	14	0.704336405	0.120769367
House Forested	-77.550	38.745	14	0.560120821	0.084266484
House Forested	-76.773	37.288	14	0.696985185	0.113363013
House Forested	-77.342	38.688	14	0.676598608	0.10713248
House Forested	-77.406	38.669	14	0.847526789	0.145284757
House Forested	-76.768	37.288	14	0.690935254	0.10438595
House Forested	-79.664	37.103	14	0.778633296	0.127379552
House Forested	-76.477	37.486	14	0.763493001	0.121369146
House Forested	-77.685	38.102	14	0.856228471	0.149628416
House Forested	-78.512	37.993	14	0.785814583	0.118620463
House Forested	-77.408	38.985	14	0.803656816	0.121105596
House Forested	-79.484	37.009	14	0.87642473	0.133529857