FOREST CONSERVATION EVALUATION TOOL (FCET)

METHODS AND DATA

Detailed instructions for using the tool are available under "Instructions."

Citing the FCET: Blackman, A. and A. Egorenkov. 2016. Forest Conservation Evaluation Tool. Washington, DC: Resources for the Future. Available at: http://fc-evaluation-tool.net

Rationale

Although tropical deforestation in Mesoamerica continues to have severe environmental impacts, the human, financial, and technical resources available to curtail it are limited. Therefore, it is critically important that these resources are spent on forest conservation policies that are effective. Unfortunately, however, credible evidence on policy effectiveness is quite scarce. We know little about whether and under what conditions community forestry, eco-certification, payments for environmental services and other leading policies actually stem deforestation .

A key reason is that the conventional approach to evaluating the effectiveness of forest conservation policies is flawed. It entails comparing the rate of deforestation inside an area affected by the policy with the rate outside. The problem with this strategy is that forest conservation policies are not randomly located. Rather, they tend to be sited in places with above- or below-average pre-existing deforestation rates—usually the latter. Evaluations that do not control for that fact conflate the effects of the policy with the effects of its location.

For example, evaluations of protected areas typically compare the rate of deforestation inside a protected area with the rate outside and attribute the difference to the protected area. But protected areas are usually sited in remote places that have low rates of deforestation to begin with. Hence, conventional evaluations wrongly give protected areas all the credit for these relatively low deforestation rates, thereby dramatically overestimating their effectiveness.

Over the past decade, a new more rigorous method for evaluating forest conservation policies has emerged. It entails the using deforestation data from satellites along with statistical methods that control for non-random siting (for an introduction, see Blackman 2013). Intuitively, these methods measure effectiveness by comparing deforestation in policy areas to deforestation nonpolicy areas that are similar in terms of the characteristics that drive deforestation such as distance to cities. That is, these techniques compare "apples-to-apples." Although evaluations of forest conservation policies using these methods have begun to appear, for the most part, they are being conducted by and for academics. Uptake by policy makers has been slow.

Two key barriers have slowed uptake. The first is the cost of the requisite data. These methods require fine-scale GIS data on forest cover change and on land characteristics, all compiled into a relational database. Collecting, cleaning and compiling these data is time and labor intensive. The second barrier has to do with technical expertise. These methods require facility with GIS and statistical software like ArcGIS, R and Stata.

Objective

The Forest Conservation Evaluation Tool (FCET) aims to overcome these barriers. It is a freely available, user-friendly webtool that has on-board all the requisite data. It is designed to allow a non-technical user to generate results in a single short session.

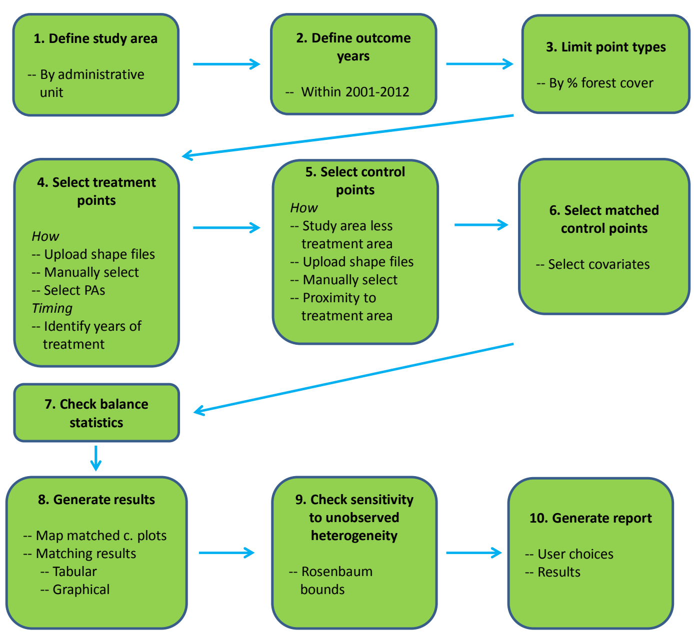
Methods overview

The FCET measures the effect on deforestation of an existing forest conservation policy. That policy must be one that affects some forest areas and not others. Examples include protected areas, eco-certification, or payments for environmental services. The FCET cannot be used to evaluate the effect of a policy like removal of logging subsidies that affects all forests in a study area.

Although it will eventually be expanded, at the FCET's current geographic scope is Mesoamerica. The underlying spatial unit of analysis is a dimensionless point. The FCET relies on a sample of more than one million points in Mesoamerica and the DR. These points were selected by overlaying a 1km rectangular grid on Mesoamerica and then selecting all points at the intersection of the gridlines that were forested in 2000.

Using these points, an estimate of the effectiveness of a forest conservation policy is generated as via the following steps (Figure 1).

Figure 1: FCET user interaction and functions



1. The user defines a *study area*: an area comprised of first-level administrative units (e.g., states in Mexico, departments in Guatemala) where the effect of the forest conservation policy is to be evaluated.

2. The user identifies *outcome years*: the range of years between 2000-2001 over which the effect of the policy on deforestation will be measured.

3. The user limits *point types*, by setting a threshold for year 2000 forest cover that will be used to define which point will be included in the analysis.

4. The user selects *treatment points*: forested points in the study area that have been affected by the forest conservation policy.

5. The user selects *control points*: points in the study area not affected by the forest conservation policy that likely to include at least some points 'similar' to those affected by the policy.

6. The FCET identifies *matched control points*: control points that are similar to treatment points. To do this the FCET uses a statistical technique called propensity score matching (PSM). To facilitate that, the user must select *control variables*: land characteristic variables ('covariates') such as slope and distance to cities that will be used to define similarity between treatment points and control points.

7. The FCET generates *balance statistics*: statistics in tabular and graphical format that give the user an idea of how similar the matched control points are to the treatment points. Further detail on PSM and balance statics is provided below.

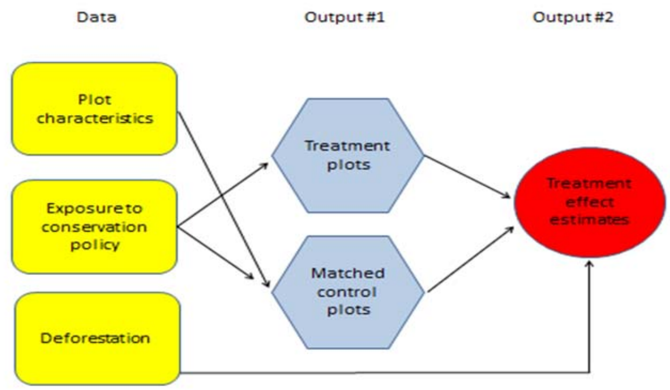
8. The FCET calculates the *forest conservation policy's effect*: the difference between the deforestation rate on treatment points and matched control points. The FCET outputs this result in tabular and graphical format. Further detail on the FCET's effect estimates is provided below.

9. The FCET checks *sensitivity to unobserved heterogeneity*: how sensitive are results from Step 8 to unobserved confounding factors. This analysis gives the user a sense of how robust and reliable are FCET results. Further detail on this sensitivity analysis is provided below.

10. The FCET outputs a *report*, that contains all of the choices the user has made, and all of the results and sensitivity analyses the FCET has generated.

The following figure sketches the FCET's conceptual framework.

Figure 2. FCET conceptual framework



The yellow rounded rectangles represent the three types of point-level spatial data that the tool uses, specifically, data on: (i) land characteristics that drive deforestation, for example, slope and proximity to cities; (ii) exposure to the conservation policies; and (iii) deforestation. The blue hexagons represent the first output of the tool: samples of (i) treatment' points; and (ii) matched control points. Finally, the red circle represents the second output of the tool: estimates of the effect of the conservation policy on deforestation.

Methods detail

Propensity score matching. Like other matching methods, propensity score matching reduces the thorny problem of comparing two units of analysis on the basis of multiple attributes to the much simpler problem of comparing them on the basis of a univariate index that represents those attributes. PSM uses multiple regression to map attributes to a univariate index (Caliendo and Kopeinig 2008; Rosenbaum and Rubin 1983). The index is generated in two steps. First a binary variable that indicates whether a unit is treated (in our case, whether a point is subject to a forest conservation policy) is regressed onto variables representing the unit's attributes (in our case, characteristics of the point such as slope and distance to a city). Next, the estimated parameters from this regression are used to predict the probability of treatment. That predicted probability is the univariate index. It is used to identify matched control points that are similar to treatment points. It can be interpreted as a weighted average of the units attributes, where the weights depend on the importance of the attributes in explaining treatment. FCTT uses 1-1 matching with replacement. That is, each treated point is matched to a control point with the closest propensity score and control points are available to be used more than one time. Eventually, FCTT will support alternative matching methods.

Balance statistics. Balance statistics indicate how similar are the subsets of treated points and control points before matching (i.e., treated points versus all control points) and after matching (i.e., treated points versus matched control points). FCTT outputs balance statistics by covariate, and across all covariates. The 'by covariate' statistics include mean of the covariate for the treated sample, the mean of the covariate for the control sample, the percent bias (the variance normalized percent difference in the two means), and results of a statistical test of the null hypothesis that the two means are equal. Lower post-matching bias and inability to reject the null hypothesis indicate that on average treated and matched control points are similar. The 'across all covariates' statistics include the mean and median standardized bias, which is mean and median across all covariates of the absolute value of the difference of variance normalized means of the treated and matched untreated subsamples. Although a clear threshold for acceptable median standardized bias does not exist, a statistic below 3–5 percent is generally viewed as sufficient (Caliendo and Kopeinig 2008). It also includes pseudo-R2 for the probit regression used to generate propensity scores. Finally, it includes statistics from a likelihood ratio test of the null hypothesis that all regressors in that probit regression are jointly insignificant.

Effect estimates. FCTT estimate of the effect of the forest conservation policy on deforestation, technically the average treatment effect on the treated (ATT) is the difference between the average deforestation rate for the treated points and the matched control points. The standard error does not take into account the fact that propensity scores are estimated. Future versions of FCTT will provide alternative methods of calculating standard errors.

Sensitivity to unobserved heterogeneity. FCTT calculates Rosenbaum bounds to check the sensitivity of effect estimates to unobserved heterogeneity (Rosenbaum 2002; Aakvik 2001). Rosenbaum bounds indicate how strongly unobserved confounding factors would need to influence selection into the treatment in order to undermine a statistically significant ATT. To be more specific, the Rosenbaum procedure adapted to a binary outcome generates a probability value for Mantel and Haenszel (1959) test statistic for a series of values of Γ, an index of the strength of the influence that unobserved confounding factors have on the selection process. $\Gamma = 1$ implies that unobserved confounding factors have no influence, such that pairs of plots matched on observables do not differ in their odds of being treated; $\Gamma = 2$ implies that matched pairs could differ in their odds of treatment by as much as a factor of two because of unobserved confounding factors; and so forth. The probability value on the Mantel and Haenszel statistic is a test of the null hypothesis of a zero ATT given unobserved confounding variables that have an effect given by Γ. So, for example, a probability value of 0.01 and a Γ of 1.2 indicate that ATT would still be significant at the one percent level even if matched pairs differed in their odds of protection by a factor of 1.2 because of unobserved confounding factors. Using our preferred nearest neighbor 1-1 covariate matching estimator as a bellwether, we calculate Γ^*, the critical value of Γ at which ATT is no longer significant at the 10 percent level in each case where ATT is significant. An ATT estimate can be considered highly sensitive to unobserved heterogeneity when Γ^* is close to unity.

Data

Table 1 describes the data that underpins the FCET.

Table 1. Data and Covariates used by FCET
(for entire region except where otherwise noted)

DATA/COVARIATE	DESCRIPTION	SCALE	SOURCE/URL
Forest cover change			
Deforestation	Hansen et al. (2013) Landsat-scale data	30m	University of MD http://www.earthenginepartner

	Annual, 2000-2010		s.appspot.com/science-2013-global-forest/download.html
Percent forest cover	Hansen et al. (2013) Landsat-scale data Single year: 2000	30m	University of MD http://www.earthenginepartners.appspot.com/science-2013-global-forest/download.html
Distance to Clearing	Hansen et al. (2013) Landsat-scale data Single year: 2000	30m	University of MD http://www.earthenginepartners.appspot.com/science-2013-global-forest/download.html
Geophysical			
Annual temperature	NASA (2001) Average annual temperature in year t (^{o}K) 2000-2012	1 km	NASA lpdaac.usgs.gov/products/modis_products_table/mod11a2
Annual rainfall	Huffman et al. (2012) Total annual rainfall in year t (mm) 2000-2012	25 km	NASA disc.sci.gsfc.nasa.gov/precipitation/documentation/TRMM_README/TRMM_3B43_readme.shtml
Aspect	Farr et al. (2007) 2000 data Directional orientation (^{0})	3arc Sec (~90m)	NASA Shuttle Radar Topography Mission http://srtm.csi.cgiar.org/ www2.jpl.nasa.gov/srtm
Elevation	Farr et al. (2007) 2000 data Elevation (m)	3arc Sec (~90m)	NASA Shuttle Radar Topography Mission http://srtm.csi.cgiar.org/ www2.jpl.nasa.gov/srtm
Slope	Farr et al. (2007) 2000 data Slope (100*tan(π angle/180)	3arc Sec (~90m)	NASA Shuttle Radar Topography Mission http://srtm.csi.cgiar.org/ www2.jpl.nasa.gov/srtm
Population Density	CIESIN-CIAT (2005) Gridded Population of the World	2.5 arc-minute (~4.63 km)	CIESIN-CIAT http://sedac.ciesin.columbia.edu/data/collection/gpw-v3/sets/browse
Distance to City	Euclidian distance to cities calculated in ArcGIS; city location from ESRI World Populated Places Point for 2011.	1:250,000	ESRI http://www.arcgis.com/home/item.html?id=587c838521864164acd245ea03315006
Travel time	Nelson (2008) Estimated travel time to nearest city 50K+ (minutes).	30 arc-sec	European Union Joint Research Centre http://bioval.jrc.ec.europa.eu/products/gam/download.htm
Institutional			
Administrative units	Global Administrative Areas (GADM) States and municipalities (Levels 1&2) No lower level administrative units	n/a	Global Administrative Areas (GADM) www.gadm.org
Cadasteral/tenure data (Mexico only)	Registro Agrario Nacional (RAN). Undated.	Forest management unit (ejido, communidad, etc.)	Registro Agrario Nacional (RAN)
Opportunity costs			
Opportunity Costs	Naidoo and Iwamura (2007) Annual potential gross revenues from agriculture ($USD/ha)	5 min grid (9*9 km)	http://www.stanford.edu/~takuya/downloads.htm
Land use/cover policy			
Protected areas	World Database on Protected Areas (WDPA) Version current up to and including March 31, 2010	1:50000 to 1:1,000,000 (various by regions)	World Database on Protected Areas (WDPA) http://staff.glcf.umd.edu/sns/branch/htdocs.sns/data/wdpa/

REFERENCES

Aakvik, A. 2001. Bounding a matching estimator: The case of a Norwegian training program. *Oxford Bulletin of Economics and Statistics* 63: 115–143.

Blackman, A. 2013. Evaluating forest conservation policies in developing countries using remote sensing data: An introduction and practical guide. *Forest Policy and Economics* 34:1-16.

Caliendo, M., and S. Kopeinig. 2008. Some practical guidance for the implementation of propensity score matching. *Journal of Economic Surveys* 32: 31–72.

Center for International Earth Science Information Network (CIESIN), Columbia University; and Centro Internacional de Agricultura Tropical (CIAT). 2005. Gridded population of the world, Version 3 (GPWv3). Palisades, N.Y.: Socioeconomic Data and Applications Center (SEDAC), Columbia University. Available at http://sedac.ciesin.columbia.edu/gpw.

Dobson, J. E., E. A. Bright, P. R. Coleman, and B.L. Bhaduri. 2003. LandScan: A global population database for estimating populations at risk. In V. Mesev (ed.), *Remotely Sensed Cities*. London: Taylor and Francis, 267–81.

Farr, T.G., et al. 2007. The shuttle radar topography mission. *Reviews of Geophysics* 45.

Friedl, M., D. Sulla-Menashe, B. Tan, A. Schneider, N. Ramankutty, A. Sibley, and X. Huang. 2010. MODIS Collection 5 global land cover: Algorithm refinements and characterization of new datasets. *Remote Sensing of Environment* 114: 168–82.

Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. High-resolution global maps of 21st-century forest cover change. *Science* 342 (15 November): 850–53.

Hijmans, R., S. Cameron, J. Parra, P. Jones, and A. Jarvis. 2005. Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology* 25: 1965–78. Available at http://www.worldclim.org

Huffman, G.J., E.F. Stocker, D.T. Bolvin, E.J. Nelkin, R.F. Adler, 2012, last updated 2013: *TRMM Version 7 3B42 and 3B43 Data Sets*. NASA/GSFC, Greenbelt, MD.

Instituto Nacional de Ecología y Cambio Climáctico (INECC). 2011. Datos por el Indice de Presión Economica de la Deforestación.

Instituto Nacional de Estadística y Geografía (INEGI). 2013. INEGI. Continuo de Elevaciones Mexicano 3.0.

Mantel, N., and W. Haenszel. 1959. Statistical aspects of the analysis of data from retrospective studies. *Journal of the National Cancer Institute* 22: 719–748.

Naidoo, R., and T. Iwamura. 2007. Global-scale mapping of economic benefits from agricultural lands: Implications for conservation priorities. *Biological Conservation* 140: 40–49.

National Aeronautics and Space Administration (NASA). 2001. Land Processes Distributed Active Archive Center (LP DAAC). MOD11A2. USGS/Earth Resources Observation and Science (EROS) Center, Sioux Falls, South Dakota.

Nelson, A. 2008. Estimated travel time to the nearest city of 50,000 or more people in year 2000. Global Environment Monitoring Unit - Joint Research Centre of the European Commission, Ispra Italy.

Registro Agrario Nacional (RAN). Undated. Land tenure data for Mexico.

Rosenbaum, P. 2002. *Observational Studies*. 2nd ed. New York: Springer.

Rosenbaum, P., and D. Rubin. 1983. The central role of the propensity score in observational studies for causal effects. *Biometrika* 70: 41–55.

Secretaría de Agricultura Ganadería Desarrollo Rural Pesca Alementación (SAGARPA), 2011a. Anuario estadístico de la producción agrícola. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación.

Secretaría de Agricultura Ganadería Desarrollo Rural Pesca Alementación (SAGARPA). 2011b. Listado de Beneficiarios 2011, PROCAMPO. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación.