# Method Correction

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1/21/2022

## Contents



## Summary

Thanks to feedback from colleagues, we have identified some errors in the SEDAC Global Human Influence Index dataset. Notably, there are some island areas that are heavily populated or otherwise obviously impacted by humans that return a false HII value of zero, indicating no human impacts. Here, we have removed these values from our dataset and reanalyzed the data. The results are almost identical to those in the main text of the paper, with no major interpretations changing. That said, we feel it important to point out the deficiency in this underlying dataset for future users.

We advise that future work utilize other global human impact databases that are more appropriate for coral reefs, such as Andrello et al "Global Human Pressure on Reefs" metric (referred to here and in our manuscript as WCS score) and Cinner et al's Human Gravity.

Details on HII and WCS Score are provided in the following tabs.

# HII details and error identification

The Global Human Influence Index (**HII**) is a globally gridded dataset with 1 km resolution grid cells. It was generated in 2005 by the NASA Socioeconomic Data and Applications Center (SEDAC) through a collaboration between the Wildlife Conservation Society (WCS) and the Columbia University Center for International Earth Science Information Network.

HII website and data download

Citation: Wildlife Conservation Society - WCS, and Center for International Earth Science Information Network - CIESIN - Columbia University. 2005. Last of the Wild Project, Version 2, 2005 (LWP-2): Global Human Influence Index (HII) Dataset (Geographic). Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). https://doi.org/10.7927/H4BP00QC.

## HII Metric Details

HII is a composite metric of human influence that includes the following layers: -Human population pressure (via human population density/ sq. km). Values from 0-10 assigned based on population density per square km - Human land use and infrastructure (via urban areas, nighttime lights and land use/land cover) - Urban area: if inside an urban polygon = 10, if outside = 0 - Light: ranked scores from 0-10 based on nighttime light values - Land use: Urban areas = 10, irrigated ag = 8, rain-fed ag = 3, other cover = 0 - Human access (via coastlines, roads, railroads, and navigable rivers) - Influence of coastlines was given 0 influence if > 15km from a coastline and 4 influence if within 15 km of a coastline - Roads were assigned an influence score based on proximity. If a site was within 2 km of a major road, it received the highest score (8), between 2 and 15 km received a 4, and > 15 km from a major road received a 0 - Railroads were scored as 0 if > 2 km from a railroad and 8 if within 2 km of a railroad - Navigable rivers received a 0 score if > 15 km from a river and 4 if within 15 km of a river The metric is calculated by assigning an influence score to various values in each layer (higher = more human influence). After values are assigned to each layer of the metric, they are summed to give an HII value.

HII metric calculation website

## Error Identification

Through expert feedback and detailed exploration of the dataset, we have identified a number of location in which HII is falsely reported to by zero (HII=0). An HII value of zero suggests no human impact on that site.

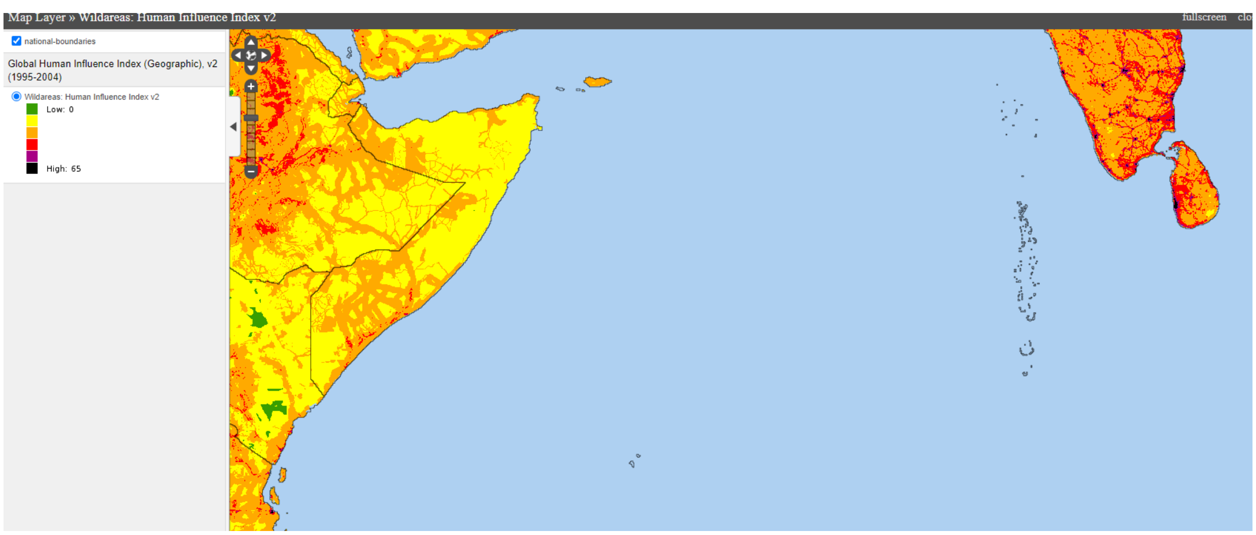

Figure 1: Map of HII data from the SEDAC webpage. Gray areas indicate missing data. In these locations, HII=0.

As a result of this missing data in the underlying HII layer, we combed our dataset and assessed each site in which HII=0 using Google Earth. Since we calculated HII for the manuscript as the sum of all HII within 100km of each site, we created a 100km radius circle on Google Earth with the lat/long of the site at the center and assessed (visually) whether there was clearly human influence or not. Since HII was generated in 2009, we utilized modern satellite imagery (the most recent available images) and images from 2008 and/or 2009 at each site. In some cases, there was very clearly human influence (Fig 2). In these instance, we removed the point from our dataset and reanalyzed. In other cases, there was no visible human influence within 100km. These sites were retained (Fig 3).


Fig 2: Maduvvari had clear human influence and was removed from the dataset.

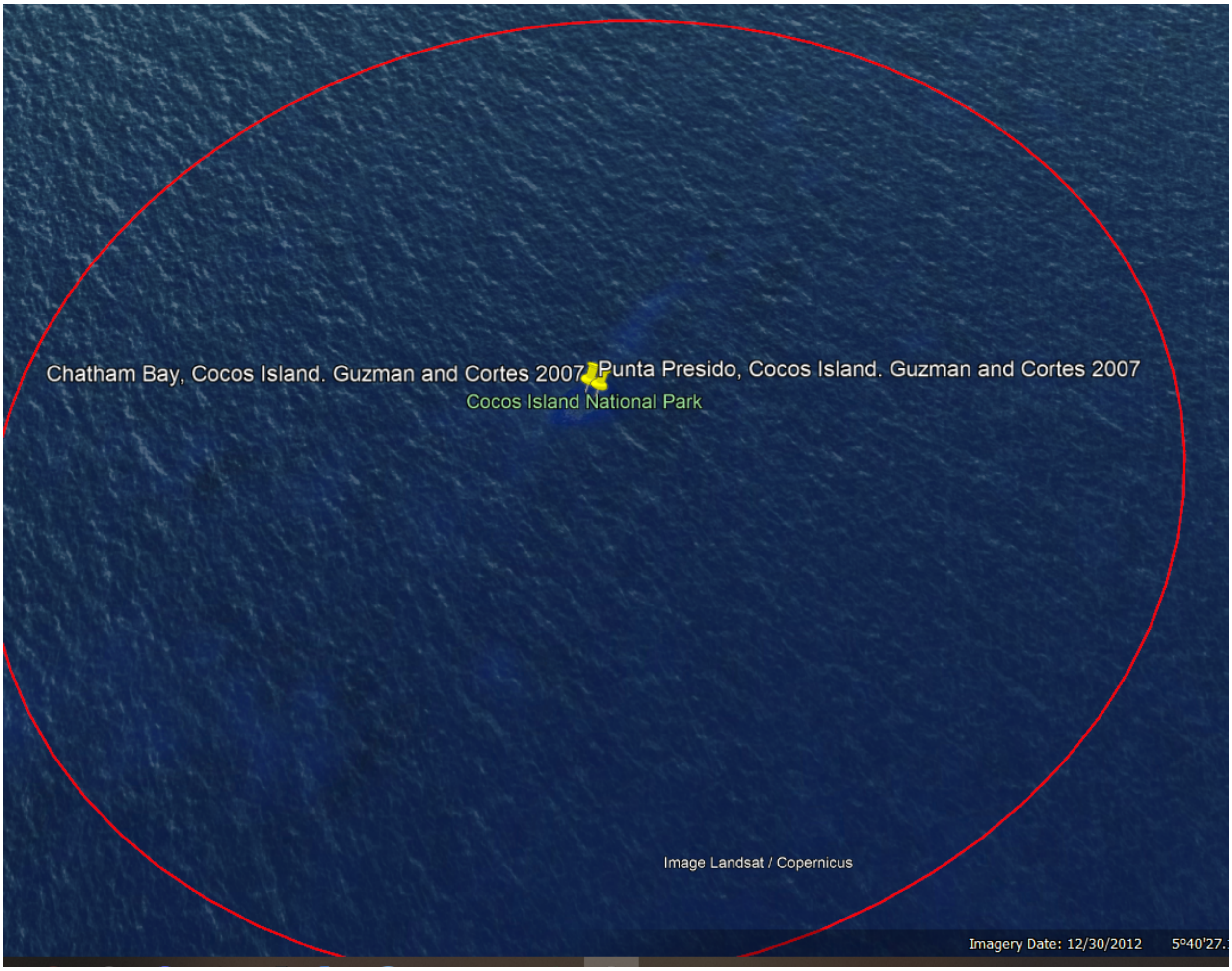


Figure 3: Cocos Island, Costa Rica had no visible human influence and was retained.

### Data Removal

After exploring the data, we removed 41 sites from our Recovery database (out of an original 182) and 40 sites from our resistance database (out of an original 184). Most of these removals were in the Indian Ocean. It seems that the missing data in the HII dataset are concentrated in small island states, specifically within the Indian Ocean. We urge caution in using this dataset for this region of the world in the future and note that such gaps do not appear to exist in the Andrello et al WCS score or the Cinner et al Human Gravity data.

## WCS Score Details

Explore these tabs for details on the WCS Score metric (along with links to download the data)

### WCS Score Background

WCS Score is derived from a pre-print written by Marco Andrello, Emily Darling, Amelia Wenger, Andres F. Suarez-Casto, Sharla Gelfand, and Gabby Ahmadia that is available on BiorXiv. The paper is a collaboration between The National Research Council (Italy), MARBEC (University of Montpelier, France), Wildlife Conservation Society (WCS), and a number of other institutions. Link to paper

The Supplementary Info are very helpful and contain details of each component of the metric Download Supplementary Info

Data and Code

Citation: A global map of human pressures on tropical coral reefs Marco Andrello, Emily Darling, Amelia Wenger, Andrés F. Suárez-Castro, Sharla Gelfand, Gabby N. Ahmadia bioRxiv 2021.04.03.438313; doi: https://doi.org/10.1101/2021.04.03.438313

### Metric Details

'WCS Score' is a composite metric that utilizes the following layers: - Tropical coral reef locations (from Beyer et al 2018, based on UNEP-WCMC dataset from 2010). Resolution is ~ 5km. - Fishing (Market Gravity from Cinner et al 2016, 2018, resolution = 10km) - Coastal Development (gridded population of the world from SEDAC, 2018 – an updated version of the same data used in HII. They used number of people living within a 5km buffer of each reef polygon as the actual metric here) - Industrial Development (World port locations- ports were identified from a google data product, given a point location, and then all port points within 5 square km of a reef were summed) - Tourism (This value is directly from Spalding et al 2017 – an estimate of the annual economic value of each reef) - Sediment Pollution (Via a newly calculate metric for this paper- Sediment delivery from rivers was estimated in 2 ways based on land cover, management, rainfall, discharge, land use, and more. Sediment exposure to reefs was modelled using sediment plume models and estimated at tons of sediment per square km) - Nitrogen Pollution (Using FAO data on catchment level crop cover and national nitrogen fertilizer use, they modeled nitrogen plumes from rivers to estimate nitrogen pollution)

Each metric was assigned a weight (1-6 with 6 meaning most impactful) for each reef pixel using perceptions of risk from a study by Stephanie Wear (2016). A weighed average of the 6 metrics was used to generate a cumulative score, or as we are calling it, 'WCS Score' for each pixel.

See supplementary methods from Andrello et al for more detail on all of these metrics and how they were calculated.

## Updated Tables and Figures

### Tables

#### Updated Recovery Model Table

```
##                          Parameter Coefficient        SE   CI        CI_low
## 1                      (Intercept)  0.61595530 1.4456038 0.95  -2.252081531
## 2                  regionE. Pacific  0.86260226 1.6261043 0.95  -2.363542320
## 3               regionIndian Ocean  0.49072811 1.6541673 0.95  -2.791092752
## 4                  regionW. Pacific  2.26851198 1.4381334 0.95  -0.584703654
## 5       disturbanceBleaching, COTS -1.06138012 2.0570847 0.95  -5.142577625
## 6   disturbanceBleaching, Disease -7.19140992 2.9729602 0.95 -13.089678345
## 7     disturbanceBleaching, Storm -3.38847425 1.4679047 0.95  -6.300755321
## 8                  disturbanceCOTS -1.52773350 1.2577732 0.95  -4.023119754
## 9               disturbanceDisease -2.43122902 2.0111592 0.95  -6.421311615
## 10                disturbanceStorm  0.82737795 1.2119434 0.95  -1.577083187
## 11                      hii100km2  0.55099373 0.4735701 0.95  -0.388555796
## 12              MPA_during_recovYes -0.15713513 0.6814394 0.95  -1.509091457
```

```
## 13               recovery_time2 -0.49464258 0.4063243 0.95  -1.300778363
## 14          distance_to_shore_m2 -0.06440552 0.4004037 0.95  -0.858795093
## 15                     cml_scr2  0.16079829 0.4121551 0.95  -0.656905677
## 16                  pre.dist.cc  0.02524042 0.0174126 0.95  -0.009305685
## 17               SD (Intercept)  2.44200869        NA 0.95            NA
## 18            SD (Observations)  2.00593203        NA 0.95            NA
##        CI_high          t df_error          p Effects    Group
## 1   3.48399213  0.4260886      100 0.67095903   fixed
## 2   4.08874684  0.5304717      100 0.59696099   fixed
## 3   3.77254897  0.2966617      100 0.76734008   fixed
## 4   5.12172761  1.5774003      100 0.11786175   fixed
## 5   3.01981738 -0.5159633      100 0.60701904   fixed
## 6  -1.29314150 -2.4189392      100 0.01737343   fixed
## 7  -0.47619319 -2.3083749      100 0.02303724   fixed
## 8   0.96765276 -1.2146335      100 0.22736628   fixed
## 9   1.55885356 -1.2088695      100 0.22956356   fixed
## 10  3.23183908  0.6826870      100 0.49638314   fixed
## 11  1.49054327  1.1634894      100 0.24739970   fixed
## 12  1.19482119 -0.2305930      100 0.81810212   fixed
## 13  0.31149320 -1.2173592      100 0.22633255   fixed
## 14  0.72998405 -0.1608515      100 0.87253490   fixed
## 15  0.97850225  0.3901402      100 0.69726262   fixed
## 16  0.05978653  1.4495491      100 0.15031325   fixed
## 17          NA         NA       NA         NA  random    study
## 18          NA         NA       NA         NA  random Residual
```

**Updated Resistance Model Table**

```
##                     Parameter Coefficient         SE   CI      CI_low
## 1                 (Intercept)  11.5106568 4.79554279 0.95   1.9690309
## 2             regionE. Pacific  -5.7378136 7.25440074 0.95 -20.1717955
## 3           regionIndian Ocean   1.7274082 6.17142113 0.95 -10.5517840
## 4             regionW. Pacific  -7.7074993 5.17012828 0.95 -17.9944328
## 5   disturbanceBleaching, COTS -10.5828188 7.36410103 0.95 -25.2350699
## 6  disturbanceBleaching, Storm -12.4616494 6.65553584 0.95 -25.7040780
## 7              disturbanceCOTS -10.4173519 4.78119305 0.95 -19.9304263
## 8           disturbanceDisease  -8.5517700 8.75664746 0.95 -25.9747517
## 9             disturbanceStorm  -6.5298251 4.30237822 0.95 -15.0902082
## 10                   hii100km2  -1.8204206 2.21722729 0.95  -6.2320074
## 11         MPA_during_resistYes  -5.4074026 2.96585208 0.95 -11.3085179
## 12           resistance_time_2  -2.4712555 1.81139863 0.95  -6.0753705
## 13                    cml_scr2  -1.5865288 1.84850657 0.95  -5.2644770
## 14          travel_time.tt_pop2  -5.0241856 2.06196128 0.95  -9.1268417
## 15                 pre.dist.cc  -0.6933835 0.06941208 0.95  -0.8314918
## 16              SD (Intercept)   9.1492581         NA 0.95          NA
## 17           SD (Observations)   7.0576701         NA 0.95          NA
##       CI_high          t df_error            p Effects    Group
## 1  21.0522827  2.4002824       81 1.867568e-02   fixed
## 2   8.6961683 -0.7909425       81 4.312874e-01   fixed
## 3  14.0066004  0.2799044       81 7.802644e-01   fixed
## 4   2.5794342 -1.4907753       81 1.399046e-01   fixed
## 5   4.0694323 -1.4370822       81 1.545463e-01   fixed
## 6   0.7807792 -1.8723736       81 6.476354e-02   fixed
## 7  -0.9042775 -2.1788185       81 3.225128e-02   fixed
```

```
## 8    8.8712117 -0.9766032       81 3.316734e-01   fixed
## 9    2.0305580 -1.5177246       81 1.329773e-01   fixed
## 10   2.5911662 -0.8210347       81 4.140364e-01   fixed
## 11   0.4937127 -1.8232206       81 7.195917e-02   fixed
## 12   1.1328596 -1.3642803       81 1.762580e-01   fixed
## 13   2.0914194 -0.8582760       81 3.932727e-01   fixed
## 14  -0.9215294 -2.4366052       81 1.701824e-02   fixed
## 15  -0.5552753 -9.9893781       81 8.903453e-16   fixed
## 16          NA         NA       NA           NA  random    study
## 17          NA         NA       NA           NA  random Residual
```

## Figures

### Updated Figure 1 (regional trends)

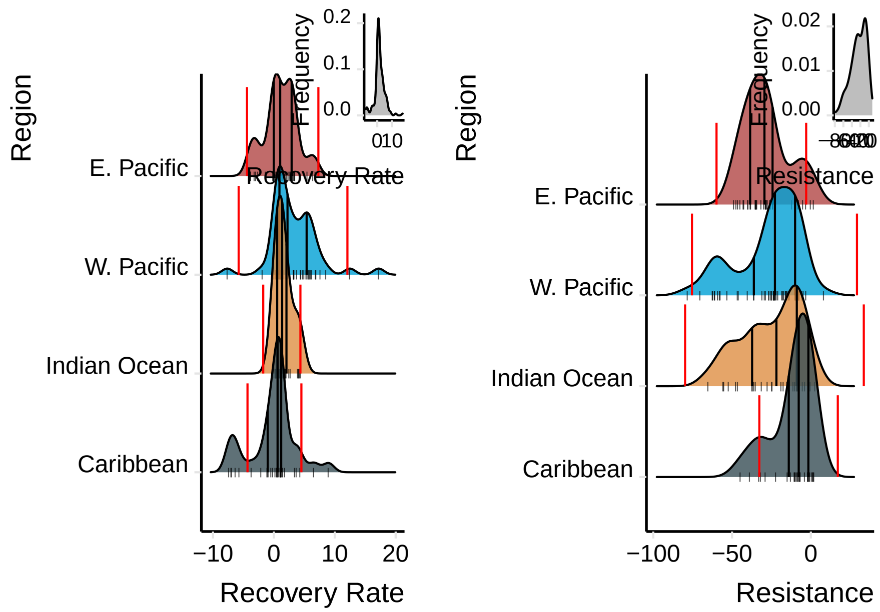


Figure 1 is very similar to the published figure. The only noticeable difference is in the Indian Ocean histrogram in panel A (Recovery Rate), where the distribution is unimodal instead of bimodal.

### Updated Manuscript Figure 2 (model coefficient plots)

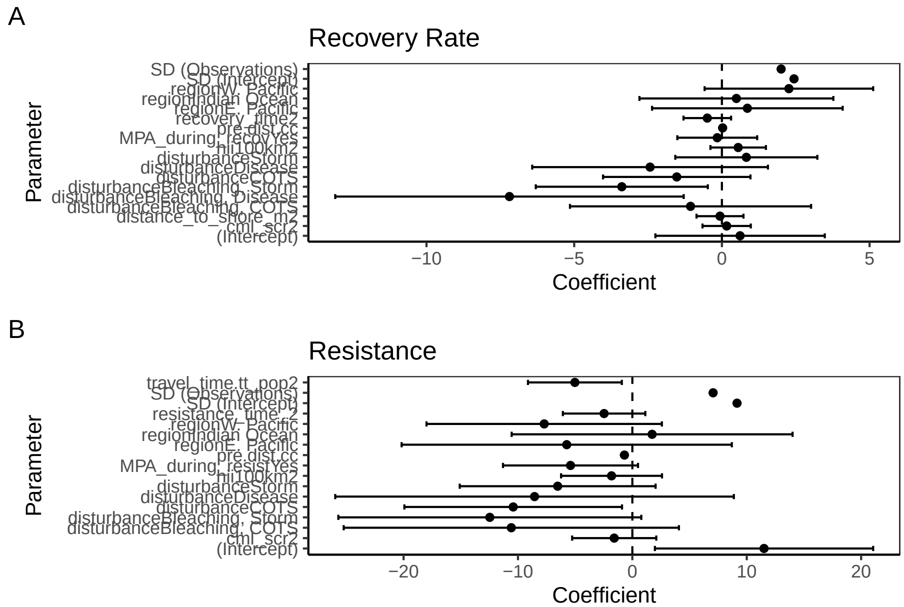


Figure 2 has changed slightly. For this version, WCS SCORE is called 'cml_scr2'. There are slight changes to some of the model coefficients following the removal of false HII=0 sites. Namely, HII is no longer (significantly) positively correlated with Recovery Rate, though that trend still appears to be present in Figure 3.

**Updated Manunscript Figure 3 (HII/WCS Score vs. Recovery/Resistance)**

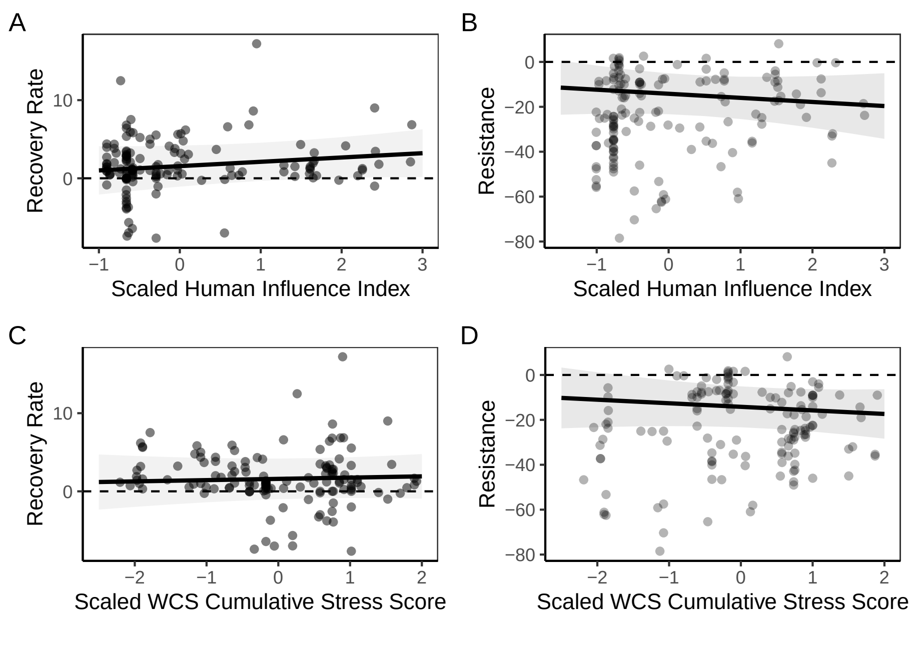


Figure 3 has changed slightly from the main text. Panels A and B there are fewer HII=0 points, as many of these were false zeros and have been removed in the re-analysis. There were no apparent trends in Panels B, C, and D in the orignal text and this remains true. In Panel A, though there is a hint of a positive correlation between HII and Recovery Rate, this is no longer statistically significant. In short, there are no clear relationships between either human influence metric and Recovery or Resistance.