**Introduction**

Turbine Height Limits/Exclusions for dWind are based on Two Major Siting Considerations:

1. Intensity of Land Development and Residential Density
2. Tree Canopy Density and Height

**Land Development and Residential Density**

Developers commonly use parcel size as an indicator of the feasibility of installing different size turbines, particularly in the case of residential customers. Nationwide parcel datasets are not freely available; therefore, as an alternative we use use data on the **number of housing units per acre** from the Census 2010 at the block-level. Blocks are the smallest available “region” for Census data. Most of the time, they are literal “blocks” in the sense of “city blocks” — small areas bounded by streets on all sides. In rural areas, they tend to be a lot larger, and may be bounded by other physical or manmade features (e.g., railroads, streams, etc.). Even in rural cases, however, they tend to be drawn in such a way to only include a small number of individual housing structures. I’ve done a lot of visual inspection of blocks for areas that I am familiar with in rural, suburban, and urban areas, and I think they will allow us to capture spatial heterogeneity in housing density about as well as the population grid data we were using previously, but will give us a more useful metric to evaluate siting restrictions (housing units per acre or acres per housing unit).

Generally speaking, commercial and industrial customers will be sited in different locations than residential customers. In these areas, the consideration is again the density of structures per unit area; however, there is no dataset for commercial/industrial that is equivalent to the spatial resolution and level of detail that Census block data offers for residential. Therefore, to account for heavily developed commercial industrial/commercial areas, we use the National Land Cover Dataset (2011), which has categorized the entire US into 20 classification of land use/land cover. The dataset accounts for four classes for developed land, including: “Open Space”, “Low Intensity”, “Medium Intensity”, and “High Intensity”. We apply only the “High Intensity” classification as a siting criteria. It is defined as “highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover” (http://www.mrlc.gov/nlcd11\_leg.php). Given the intensity of development associated with this land class, we use it as a blanket restriction on distributed wind development.

assume:

- each turbine height requires minimum hub height radius setback (e.g., 80 m turbine must be 80 m distance from structure and or property line)

- also assume best case scenario is that turbine can be placed in the very corner of a parcel (this is optimistic for wind development). if that's the case, then it's reasonable to assume that the turbine will need slightly more than just its pi\*r2 area -- so for simplicity, assume it instead needs the area of a square of that size ((2\*r)\*\*2). then the followin area is needed for each of the turbine heights:

- 20 m - 1600 m2

- 30 m - 3600 m2

- 40 m - 6400 m2

- 50 m - 10,000 m2

- 80 m - 25,600 m2

- for each candidate comm/industrial facility we assume a 200 m x 200 m area, which corresponds to a total area of 40,000 m2 (~10 acres). assuming a best case scenario where all developed land is in the optimal configuration for a turbine installation and setback, the area requirements described above correspond to maximum percent developed land as follows:

- 20 m: <= 96% developed

- 30 m: <= 91% developed

- 40 m: <= 84% developed

- 50 m: <= 75% developed

- 80 m: <= 26% developed

To account for mixed use areas (i.e., multiple market sectors in the same location), we apply both the Census Block and NLCD based restrictions to all land masks in the model.

**Tree Canopy Density and Height**

Canopy-based siting restrictions are calculated at 200 m by 200 m horizontal resolution. As an initial cut, we identify grid cells that have a percent canopy cover greater than or equal to 20 percent. Areas below this threshold are considered to have no canopy-based siting restrictions and are only subject to siting restrictions based on population density. For areas exceeding the 20 percent canopy cover, turbines must be built at a minimum tower height relative to the average canopy height.

To determine the minimum required tower height, we determined a typical clearance above tree cover required for each turbine size (e.g., 10 m clearance for a 10 kw turbine). We then add this clearance requirement to the average canopy height, and determine the minimum required tower height for the turbine size at each location.

The resulting turbine size and minimum required tower height will be cross-referenced with the turbine size-turbine height matrix used in the model to determine whether the size/height combination is valid and feasible given current construction norms.

**Detailed Exclusions Process Methodology**

**Data Sources:**

* Census Block 2010 Shapefiles and table H1 (from NHGIS.org)
* NLCD 2011 Land Cover (http://www.mrlc.gov/nlcd11\_data.php)
* NLCD 2011 USFS Tree Canopy Analytical (http://www.mrlc.gov/nlcd11\_data.php)
* National Biomass and Carbon Dataset (2000): Average Canopy Height (http://www.whrc.org/mapping/nbcd/)

The end goal is to populate each of the sector point grid tables in postgres with the following attributes:

* hi\_dev\_pct (Integer): Percent of Grid Cell that is Developed High Intensity (NLCD Class 24)
* acres\_per\_hu (Numeric): Acres per housing unit (from Census 2010 BLock Level data)
* canopy\_pct (Boolean): Percent canopy cover from NLCD > 25%
* canopy\_ht\_m (Integer): Average canopy cover height

**hi\_dev\_pct (Integer): Percent Developed High Intensity (NLCD 2011 Class 24)**

* In ArcGIS, reproject/resample nlcd\_2006\_landcover\_2011\_edition\_2014\_10\_10.img to WGS84, with the following parameters:
  + Geoprocessing Environments: Extent and Snap Raster = F:\data\mgleason\aws\_2014\_update\gis\conus\cf\_rasters\derived\onshoremask
  + Resampling Technique: Nearest (do NOT use Majority because it will cause a smoothing effect that elimates isolated grid cells)
  + Output Cell Size: 0.0003 (decimal degrees)
  + Output Raster: F:\data\mgleason\DG\_Wind\Data\Analysis\nlcd\_2011\nlcd\_wgs84\_nn
  + \*\* This effectively resamples the raster to roughly the same resolution, but at a cell size and alignment that is evenly divisible within the 0.0018 decimal degree grid cells used as the standard resolution in the model
* Extract Class 24 to separate Boolean raster (values of 1 where class =24, no data everywhere else):
* Run raster Calculator with expression Extract Class 24 to separate Boolean raster (values of 1 where class =24, no data everywhere else):
  + Run raster Calculator with expression Con("nlcd\_wgs84\_nn" == 24,1)
  + F:\data\mgleason\DG\_Wind\Data\Analysis\nlcd\_2011\cl24\_wgs84
* Run Aggregate tool to count the number of class 24 grid cells in each larger 0.0018 grid cell
  + Cell Factor = 6
  + Aggregate Technique = Sum
  + Output raster: F:\data\mgleason\DG\_Wind\Data\Analysis\nlcd\_2011\cl24\_count
* Convert conts to a percent value as an integer in range 0-100
  + Run Raster Calculator: Int((Float("cl24\_count")/36.0 \* 100)+0.5)
  + Output raster: F:\data\mgleason\DG\_Wind\Data\Analysis\nlcd\_2011\cl24\_pct
* Load to Postgres:
  + raster2pgsql -s 4326 -b 1 -t 100x100 -I -M -C -Y cl24\_pct **diffusion\_wind\_data.nlcd\_2011\_cl24\_pct\_100x100**|psql -h gispgdb.nrel.gov -U mgleason dav-gis

**canopy\_pct (Integer): Percent canopy cover from NLCD 2011**

* Extract by mask to remove values of zero around the borders:
  + Mask:F:\data\mgleason\DG\_Wind\Data\Analysis\nlcd\_2011\nlcd2011\_no0
  + Output: F:\data\mgleason\DG\_Wind\Data\Analysis\nlcd\_2011\can\_pct\_msk
* In ArcGIS, run Aggregate in Spatial Analyst (MEAN with cell factor of 6) to effectively resample the data to 180 m x 180 m resolution
  + F:\data\mgleason\DG\_Wind\Data\Analysis\nlcd\_2011\can\_pct\_180
* Reproject/resample output to ~200 m resolution, coregistered to the new wind GCF data
  + Set geoprocessing environments (extent, cell size, mask, and snap raster) to
    - F:\data\mgleason\aws\_2014\_update\gis\conus\cf\_rasters\derived\onshoremash
  + Run Project Raster, with Bilinear resampling:
    - F:\data\mgleason\DG\_Wind\Data\Analysis\nlcd\_2011\can\_pct\_rsmp
* Round the values to integer and clip to onshoremask raster
  + Use geoprocessing settings from above
  + Run Raster Calculator:
    - Int("can\_pct\_rsmp" + 0.5)
    - F:\data\mgleason\DG\_Wind\Data\Analysis\ nlcd\_2011\can\_pct\_rs\_i
* Load to Postgres:
  + raster2pgsql -s 4326 -b 1 -t 100x100 -I -M -C -Y can\_pct\_rs\_i **diffusion\_wind\_data.canopy\_pct\_100x100**|psql -h gispgdb.nrel.gov -U mgleason dav-gis

**canopy\_height\_m (Integer): Average canopy cover height**

* Input dataset (created by Britney using mosaicking):
  + F:\data\bsutcliffe\10\_20\_13\_Biomass\_Carbon\_dataset\Grid\_Files\Grid\Mosaic\raster\_full
* Convert values of zero to No Data so that they don’t skew the resampling by MEANs. Run Raster Calculator:
  + SetNull("raster\_full" ==0, "raster\_full")
  + Output: F:\data\mgleason\DG\_Wind\Data\Analysis\canopy\_height\canpy\_ht\_no0
* In ArcGIS, run Aggregate in Spatial Analyst (MEAN with cell factor of 6) to effectively resample the data to 180 m x 180 m resolution
  + F:\data\mgleason\DG\_Wind\Data\Analysis\canopy\_height\canpy\_ht\_180
* Reproject/resample output to ~200 m resolution, coregistered to the new wind GCF data
  + Set geoprocessing environments (extent, cell size, mask, and snap raster) to F:\data\mgleason\aws\_2014\_update\gis\conus\cf\_rasters\derived\onshoremash
  + Run Project Raster, with Bilinear resampling:
    - F:\data\mgleason\DG\_Wind\Data\Analysis\canopy\_height\canpy\_ht\_rsmp
* Round the values to integer and clip to onshoremask raster
  + Use geoprocessing settings from above
  + Run Raster Calculator:
    - Int("canpy\_ht\_rsmp" + 0.5)
  + F:\data\mgleason\DG\_Wind\Data\Analysis\canopy\_height\cnpy\_ht\_rsm\_i
* Load to Postgres:
  + raster2pgsql -s 4326 -b 1 -t 100x100 -I -M -C -Y cnpy\_ht\_rsm\_i **diffusion\_wind\_data.canopy\_height\_100x100**|psql -h gispgdb.nrel.gov -U mgleason dav-gis

**acres\_per\_hu (Numeric): Acres per housing unit (from Census 2010 BLock Level data)**