Applied Economics Research using R: Session 2

Geospatial Data for Applied Economics

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Contents

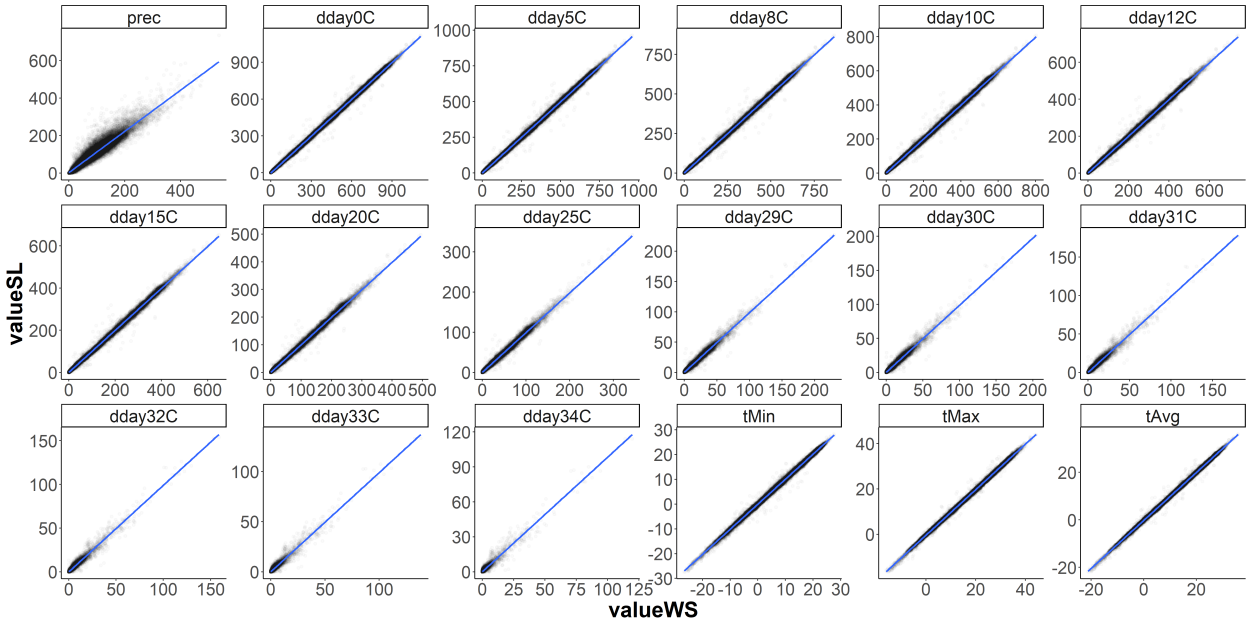
This document includes some pieces (R codes + figure) that you may find useful when constructing county-level data for degree days. The codes in this document are intended to be illustrative. As mentioned in the class, the tricky part is constructing a cropland weighting layer on the PRISM grid cells. I included this part in the exercise not because I presume you will frequently do this but because it illustrates the point that some geosptial operations could be specific to data type. If you need some geospatial operations that are allowed only for the data type you don't have, you might need to convert your data type.

The three codes below generalizes the small pieces included in this document to create the daily county-level weather data in 2019 and 2020 for all the counties in the Contiguous US. Constructed weather variables include precipitation, and degree days above 0, 5, 8, 10, 12, 15, 20, 25, 29, 30, 31, 32, 33 and 34 degree Celsius.

```
list.files("Code/", pattern = "^1")
```

```
## [1] "110_construct cropland weight grid for PRISM.R"
## [2] "120_calculate (county daily) tmin, tmax, ppt.R"
## [3] "130_calculate (county daily) degree days.R"
```

The figure below shows a comparison between my weather data and Professor Schlenker's for 2019 at the county-by-month level. Because of different choices we made in the process of data construction, there are some differences.



1 Aggregate land cover to the PRISM grid

```
source("Code/001_packages.R")
source("Code/002_functions.R")
```

```
##   |                                                                      |
```

```
file_list <- list.files("Data/prism/",
                        full.names = T,
                        pattern = "t.*2019071.*bil$",
                        recursive = TRUE) %>%
  sort()
file_list
```

```
##  [1] "Data/prism//PRISM_ppt_stable_4kmD2_20190710_bil/PRISM_ppt_stable_4kmD2_20190710_bil.bil"
##  [2] "Data/prism//PRISM_ppt_stable_4kmD2_20190711_bil/PRISM_ppt_stable_4kmD2_20190711_bil.bil"
##  [3] "Data/prism//PRISM_ppt_stable_4kmD2_20190712_bil/PRISM_ppt_stable_4kmD2_20190712_bil.bil"
##  [4] "Data/prism//PRISM_ppt_stable_4kmD2_20190713_bil/PRISM_ppt_stable_4kmD2_20190713_bil.bil"
##  [5] "Data/prism//PRISM_ppt_stable_4kmD2_20190714_bil/PRISM_ppt_stable_4kmD2_20190714_bil.bil"
##  [6] "Data/prism//PRISM_ppt_stable_4kmD2_20190715_bil/PRISM_ppt_stable_4kmD2_20190715_bil.bil"
##  [7] "Data/prism//PRISM_ppt_stable_4kmD2_20190716_bil/PRISM_ppt_stable_4kmD2_20190716_bil.bil"
##  [8] "Data/prism//PRISM_ppt_stable_4kmD2_20190717_bil/PRISM_ppt_stable_4kmD2_20190717_bil.bil"
##  [9] "Data/prism//PRISM_ppt_stable_4kmD2_20190718_bil/PRISM_ppt_stable_4kmD2_20190718_bil.bil"
## [10] "Data/prism//PRISM_ppt_stable_4kmD2_20190719_bil/PRISM_ppt_stable_4kmD2_20190719_bil.bil"
## [11] "Data/prism//PRISM_tmax_stable_4kmD2_20190710_bil/PRISM_tmax_stable_4kmD2_20190710_bil.bil"
```

```
## [12] "Data/prism//PRISM_tmax_stable_4kmD2_20190711_bil/PRISM_tmax_stable_4kmD2_20190711_bil.bil"
## [13] "Data/prism//PRISM_tmax_stable_4kmD2_20190712_bil/PRISM_tmax_stable_4kmD2_20190712_bil.bil"
## [14] "Data/prism//PRISM_tmax_stable_4kmD2_20190713_bil/PRISM_tmax_stable_4kmD2_20190713_bil.bil"
## [15] "Data/prism//PRISM_tmax_stable_4kmD2_20190714_bil/PRISM_tmax_stable_4kmD2_20190714_bil.bil"
## [16] "Data/prism//PRISM_tmax_stable_4kmD2_20190715_bil/PRISM_tmax_stable_4kmD2_20190715_bil.bil"
## [17] "Data/prism//PRISM_tmax_stable_4kmD2_20190716_bil/PRISM_tmax_stable_4kmD2_20190716_bil.bil"
## [18] "Data/prism//PRISM_tmax_stable_4kmD2_20190717_bil/PRISM_tmax_stable_4kmD2_20190717_bil.bil"
## [19] "Data/prism//PRISM_tmax_stable_4kmD2_20190718_bil/PRISM_tmax_stable_4kmD2_20190718_bil.bil"
## [20] "Data/prism//PRISM_tmax_stable_4kmD2_20190719_bil/PRISM_tmax_stable_4kmD2_20190719_bil.bil"
## [21] "Data/prism//PRISM_tmin_stable_4kmD2_20190710_bil/PRISM_tmin_stable_4kmD2_20190710_bil.bil"
## [22] "Data/prism//PRISM_tmin_stable_4kmD2_20190711_bil/PRISM_tmin_stable_4kmD2_20190711_bil.bil"
## [23] "Data/prism//PRISM_tmin_stable_4kmD2_20190712_bil/PRISM_tmin_stable_4kmD2_20190712_bil.bil"
## [24] "Data/prism//PRISM_tmin_stable_4kmD2_20190713_bil/PRISM_tmin_stable_4kmD2_20190713_bil.bil"
## [25] "Data/prism//PRISM_tmin_stable_4kmD2_20190714_bil/PRISM_tmin_stable_4kmD2_20190714_bil.bil"
## [26] "Data/prism//PRISM_tmin_stable_4kmD2_20190715_bil/PRISM_tmin_stable_4kmD2_20190715_bil.bil"
## [27] "Data/prism//PRISM_tmin_stable_4kmD2_20190716_bil/PRISM_tmin_stable_4kmD2_20190716_bil.bil"
## [28] "Data/prism//PRISM_tmin_stable_4kmD2_20190717_bil/PRISM_tmin_stable_4kmD2_20190717_bil.bil"
## [29] "Data/prism//PRISM_tmin_stable_4kmD2_20190718_bil/PRISM_tmin_stable_4kmD2_20190718_bil.bil"
## [30] "Data/prism//PRISM_tmin_stable_4kmD2_20190719_bil/PRISM_tmin_stable_4kmD2_20190719_bil.bil"
```

```
length(n)
```

```
## [1] 1
```

```
prism_S <- file_list %>%
  lapply(raster) %>%
  stack()
crs(prism_S)
```

```
## CRS arguments: +proj=longlat +datum=NAD83 +no_defs
```

1.2 Choose study area

```
il_cb <- cb %>%
  filter(STATEFP %in% "17") %>%
  st_transform(crs(prism_S))

il_cb
```

```
## Simple feature collection with 102 features and 17 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: -91.51308 ymin: 36.9703 xmax: -87.01993 ymax: 42.50848
## Geodetic CRS:  NAD83
## First 10 features:
##    STATEFP COUNTYFP COUNTYNS GEOID    NAME       NAMELSAD LSAD CLASSFP MTFCC
## 1       17      067 00424235 17067 Hancock Hancock County   06      H1 G4020
## 2       17      025 00424214 17025    Clay    Clay County   06      H1 G4020
## 3       17      185 00424293 17185  Wabash  Wabash County   06      H1 G4020
## 4       17      113 01784833 17113  McLean  McLean County   06      H1 G4020
```

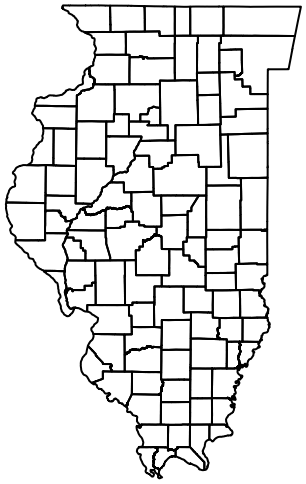
```
## 5       17      005 00424204 17005    Bond    Bond County   06      H1 G4020
## 6       17      009 00424206 17009   Brown   Brown County   06      H1 G4020
## 7       17      083 00424243 17083  Jersey  Jersey County   06      H1 G4020
## 8       17      147 00424275 17147   Piatt   Piatt County   06      H1 G4020
## 9       17      151 00424277 17151    Pope    Pope County   06      H1 G4020
## 10      17      011 00424207 17011  Bureau  Bureau County   06      H1 G4020
##    CSAFP CBSAFP METDIVFP FUNCSTAT      ALAND   AWATER    INTPTLAT     INTPTLON
## 1    161  22800     <NA>        A 2055798692 53563370 +40.4013180 -091.1688008
## 2   <NA>   <NA>     <NA>        A 1212815740  3271820 +38.7468187 -088.4823254
## 3   <NA>   <NA>     <NA>        A  578403998 10973558 +38.4458209 -087.8391674
## 4    145  14010     <NA>        A 3064600918  7801224 +40.4945594 -088.8445391
## 5    476  41180     <NA>        A  985073265  6462629 +38.8859240 -089.4365916
## 6   <NA>   <NA>     <NA>        A  791828628  4144346 +39.9620694 -090.7503095
## 7    476  41180     <NA>        A  957415147 20333975 +39.0801945 -090.3613850
## 8   <NA>  16580     <NA>        A 1137492084   754122 +40.0090327 -088.5923546
## 9   <NA>   <NA>     <NA>        A  955326683 14329536 +37.4171687 -088.5423737
## 10   176  36837     <NA>        A 2250935503 11472955 +41.4013043 -089.5283772
##                          geometry
## 1  MULTIPOLYGON (((-91.37421 4...
## 2  MULTIPOLYGON (((-88.69517 3...
## 3  MULTIPOLYGON (((-87.9446 38...
## 4  MULTIPOLYGON (((-89.2665 40...
## 5  MULTIPOLYGON (((-89.36179 3...
## 6  MULTIPOLYGON (((-90.91469 4...
## 7  MULTIPOLYGON (((-90.59216 3...
## 8  MULTIPOLYGON (((-88.74516 4...
## 9  MULTIPOLYGON (((-88.62978 3...
## 10 MULTIPOLYGON (((-89.85691 4...
```

```
attributes(il_cb)
```

```
## $names
##  [1] "STATEFP"  "COUNTYFP" "COUNTYNS" "GEOID"    "NAME"     "NAMELSAD"
##  [7] "LSAD"     "CLASSFP"  "MTFCC"    "CSAFP"    "CBSAFP"   "METDIVFP"
## [13] "FUNCSTAT" "ALAND"    "AWATER"   "INTPTLAT" "INTPTLON" "geometry"
##
## $row.names
##   [1]   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18
##  [19]  19  20  21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36
##  [37]  37  38  39  40  41  42  43  44  45  46  47  48  49  50  51  52  53  54
##  [55]  55  56  57  58  59  60  61  62  63  64  65  66  67  68  69  70  71  72
##  [73]  73  74  75  76  77  78  79  80  81  82  83  84  85  86  87  88  89  90
##  [91]  91  92  93  94  95  96  97  98  99 100 101 102
##
## $sf_column
## [1] "geometry"
##
## $agr
##  STATEFP COUNTYFP COUNTYNS    GEOID     NAME NAMELSAD     LSAD  CLASSFP
##     <NA>     <NA>     <NA>     <NA>     <NA>     <NA>     <NA>     <NA>
##    MTFCC    CSAFP   CBSAFP METDIVFP FUNCSTAT    ALAND   AWATER INTPTLAT
##     <NA>     <NA>     <NA>     <NA>     <NA>     <NA>     <NA>     <NA>
## INTPTLON
##     <NA>
```

```
## Levels: constant aggregate identity
##
## $tigris
## [1] "county"
##
## $class
## [1] "sf"         "data.frame"
```

```
plot(il_cb[, "geometry"])
```



1.3 Load land cover data

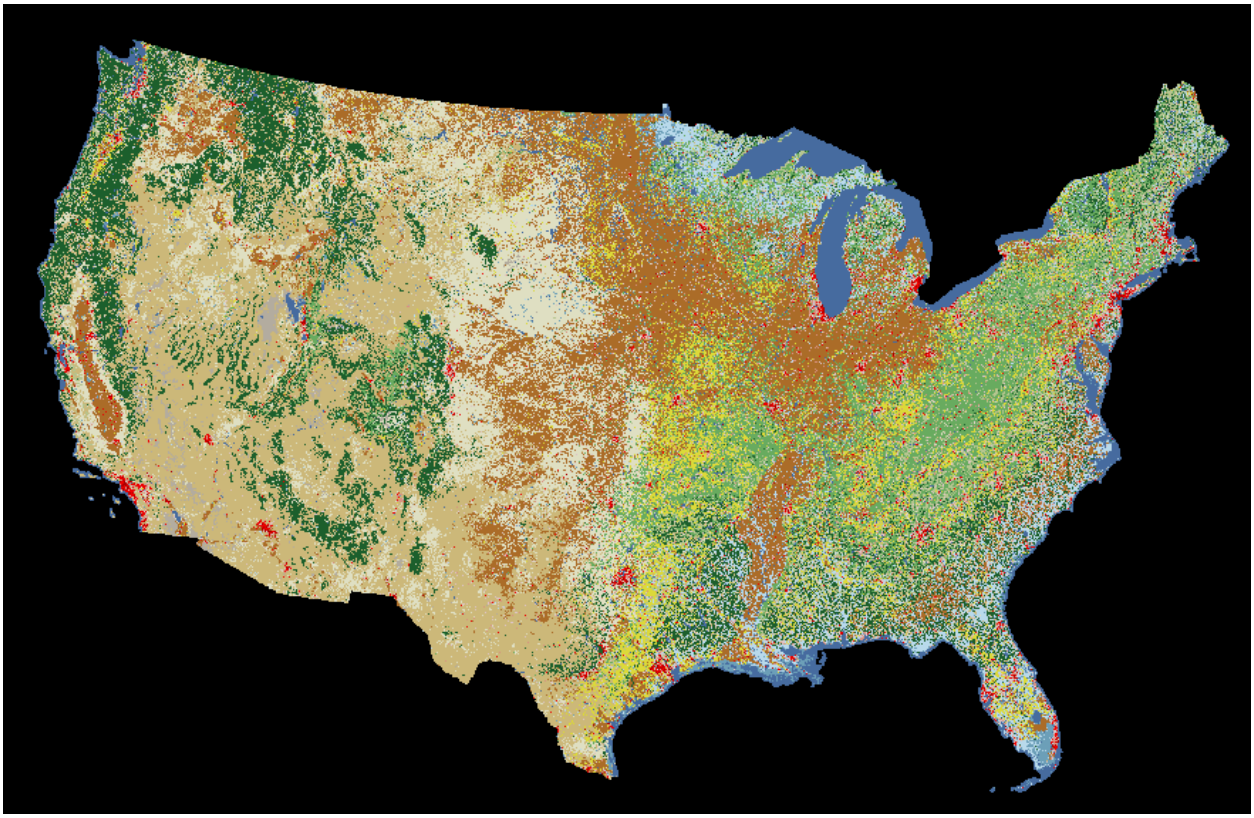
```
nlcd_R <- raster("Data/nlcd_2019_land_cover_l48_20210604/nlcd_2019_land_cover_l48_20210604.img")

nlcd_R
```

```
## class      : RasterLayer
## dimensions : 104424, 161190, 16832104560  (nrow, ncol, ncell)
## resolution : 30, 30  (x, y)
## extent     : -2493045, 2342655, 177285, 3310005  (xmin, xmax, ymin, ymax)
## crs        : +proj=aea +lat_0=23 +lon_0=-96 +lat_1=29.5 +lat_2=45.5 +x_0=0 +y_0=0 +datum=WGS84 +units
## source     : nlcd_2019_land_cover_l48_20210604.img
## names      : nlcd_2019_land_cover_l48_20210604
```

```
## values     : 0, 95  (min, max)
## attributes :
##         ID      COUNT Red Green Blue Opacity NLCD.Land.Cover.Class
##  from:   0 7853863229   0     0    0       0          Unclassified
##   to : 255          0 255   255  255     255
```

```
plot(nlcd_R)
```



```
attributes(nlcd_R)
```

```
## $file
## An object of class ".RasterFile"
## Slot "name":
## [1] "C:\\Users\\Seunghyun Lee\\Dropbox\\Teaching\\ARE231_2021\\Rsession2\\Data\\nlcd_2019_land_cover_
##
## Slot "datanotation":
## [1] "INT1U"
##
## Slot "byteorder":
## [1] "little"
##
## Slot "nodatavalue":
## [1] -Inf
##
## Slot "NAchanged":
## [1] FALSE
##
## Slot "nbands":
## [1] 1
##
## Slot "bandorder":
## [1] "BIL"
##
```

```
## Slot "offset":
## [1] 0
##
## Slot "toptobottom":
## [1] TRUE
##
## Slot "blockrows":
## [1] 512
##
## Slot "blockcols":
## [1] 512
##
## Slot "driver":
## [1] "gdal"
##
## Slot "open":
## [1] FALSE
##
##
## $data
## An object of class ".SingleLayerData"
## Slot "values":
## logical(0)
##
## Slot "offset":
## [1] 0
##
## Slot "gain":
## [1] 1
##
## Slot "inmemory":
## [1] FALSE
##
## Slot "fromdisk":
## [1] TRUE
##
## Slot "isfactor":
## [1] TRUE
##
## Slot "attributes":
## [[1]]
##       ID      COUNT Red Green Blue Opacity        NLCD.Land.Cover.Class
## 1      0 7853863229   0     0    0       0                  Unclassified
## 2      1          0   0     0    0     255
## 3      2          0   0     0    0     255
## 4      3          0   0     0    0     255
## 5      4          0   0     0    0     255
## 6      5          0   0     0    0     255
## 7      6          0   0     0    0     255
## 8      7          0   0     0    0     255
## 9      8          0   0     0    0     255
## 10     9          0   0     0    0     255
## 11    10          0   0     0    0     255
## 12    11  472399232  70   107  159     255                  Open Water
```

```
## 13   12     962418 209   222  248     255           Perennial Snow/Ice
## 14   13          0   0     0    0     255
## 15   14          0   0     0    0     255
## 16   15          0   0     0    0     255
## 17   16          0   0     0    0     255
## 18   17          0   0     0    0     255
## 19   18          0   0     0    0     255
## 20   19          0   0     0    0     255
## 21   20          0   0     0    0     255
## 22   21  240566180 222   197  197     255        Developed, Open Space
## 23   22  153288747 217   146  130     255     Developed, Low Intensity
## 24   23   92578072 235     0    0     255  Developed, Medium Intensity
## 25   24   33121466 171     0    0     255    Developed, High Intensity
## 26   25          0   0     0    0     255
## 27   26          0   0     0    0     255
## 28   27          0   0     0    0     255
## 29   28          0   0     0    0     255
## 30   29          0   0     0    0     255
## 31   30          0   0     0    0     255
## 32   31   87406005 179   172  159     255                 Barren Land
## 33   32          0   0     0    0     255
## 34   33          0   0     0    0     255
## 35   34          0   0     0    0     255
## 36   35          0   0     0    0     255
## 37   36          0   0     0    0     255
## 38   37          0   0     0    0     255
## 39   38          0   0     0    0     255
## 40   39          0   0     0    0     255
## 41   40          0   0     0    0     255
## 42   41  833976610 104   171   95     255             Deciduous Forest
## 43   42 1033039764  28    95   44     255             Evergreen Forest
## 44   43  305029988 181   197  143     255                 Mixed Forest
## 45   44          0   0     0    0     255
## 46   45          0   0     0    0     255
## 47   46          0   0     0    0     255
## 48   47          0   0     0    0     255
## 49   48          0   0     0    0     255
## 50   49          0   0     0    0     255
## 51   50          0   0     0    0     255
## 52   51          0   0     0    0     255
## 53   52 1961779404 204   184  121     255                 Shrub/Scrub
## 54   53          0   0     0    0     255
## 55   54          0   0     0    0     255
## 56   55          0   0     0    0     255
## 57   56          0   0     0    0     255
## 58   57          0   0     0    0     255
## 59   58          0   0     0    0     255
## 60   59          0   0     0    0     255
## 61   60          0   0     0    0     255
## 62   61          0   0     0    0     255
## 63   62          0   0     0    0     255
## 64   63          0   0     0    0     255
## 65   64          0   0     0    0     255
## 66   65          0   0     0    0     255
```

```
## 67   66          0   0     0    0     255
## 68   67          0   0     0    0     255
## 69   68          0   0     0    0     255
## 70   69          0   0     0    0     255
## 71   70          0   0     0    0     255
## 72   71 1198000354 223   223  194     255                    Herbaceous
## 73   72          0   0     0    0     255
## 74   73          0   0     0    0     255
## 75   74          0   0     0    0     255
## 76   75          0   0     0    0     255
## 77   76          0   0     0    0     255
## 78   77          0   0     0    0     255
## 79   78          0   0     0    0     255
## 80   79          0   0     0    0     255
## 81   80          0   0     0    0     255
## 82   81  560647664 220   217   57     255                  Hay/Pasture
## 83   82 1464715609 171   108   40     255              Cultivated Crops
## 84   83          0   0     0    0     255
## 85   84          0   0     0    0     255
## 86   85          0   0     0    0     255
## 87   86          0   0     0    0     255
## 88   87          0   0     0    0     255
## 89   88          0   0     0    0     255
## 90   89          0   0     0    0     255
## 91   90  403631293 184   217  235     255                Woody Wetlands
## 92   91          0   0     0    0     255
## 93   92          0   0     0    0     255
## 94   93          0   0     0    0     255
## 95   94          0   0     0    0     255
## 96   95  137098525 108   159  184     255 Emergent Herbaceous Wetlands
## 97   96          0  96    96   96     255
## 98   97          0  97    97   97     255
## 99   98          0  98    98   98     255
## 100  99          0  99    99   99     255
## 101 100          0 100   100  100     255
## 102 101          0 101   101  101     255
## 103 102          0 102   102  102     255
## 104 103          0 103   103  103     255
## 105 104          0 104   104  104     255
## 106 105          0 105   105  105     255
## 107 106          0 106   106  106     255
## 108 107          0 107   107  107     255
## 109 108          0 108   108  108     255
## 110 109          0 109   109  109     255
## 111 110          0 110   110  110     255
## 112 111          0 111   111  111     255
## 113 112          0 112   112  112     255
## 114 113          0 113   113  113     255
## 115 114          0 114   114  114     255
## 116 115          0 115   115  115     255
## 117 116          0 116   116  116     255
## 118 117          0 117   117  117     255
## 119 118          0 118   118  118     255
## 120 119          0 119   119  119     255
```

```
## 121 120          0 120   120  120     255
## 122 121          0 121   121  121     255
## 123 122          0 122   122  122     255
## 124 123          0 123   123  123     255
## 125 124          0 124   124  124     255
## 126 125          0 125   125  125     255
## 127 126          0 126   126  126     255
## 128 127          0 127   127  127     255
## 129 128          0 128   128  128     255
## 130 129          0 129   129  129     255
## 131 130          0 130   130  130     255
## 132 131          0 131   131  131     255
## 133 132          0 132   132  132     255
## 134 133          0 133   133  133     255
## 135 134          0 134   134  134     255
## 136 135          0 135   135  135     255
## 137 136          0 136   136  136     255
## 138 137          0 137   137  137     255
## 139 138          0 138   138  138     255
## 140 139          0 139   139  139     255
## 141 140          0 140   140  140     255
## 142 141          0 141   141  141     255
## 143 142          0 142   142  142     255
## 144 143          0 143   143  143     255
## 145 144          0 144   144  144     255
## 146 145          0 145   145  145     255
## 147 146          0 146   146  146     255
## 148 147          0 147   147  147     255
## 149 148          0 148   148  148     255
## 150 149          0 149   149  149     255
## 151 150          0 150   150  150     255
## 152 151          0 151   151  151     255
## 153 152          0 152   152  152     255
## 154 153          0 153   153  153     255
## 155 154          0 154   154  154     255
## 156 155          0 155   155  155     255
## 157 156          0 156   156  156     255
## 158 157          0 157   157  157     255
## 159 158          0 158   158  158     255
## 160 159          0 159   159  159     255
## 161 160          0 160   160  160     255
## 162 161          0 161   161  161     255
## 163 162          0 162   162  162     255
## 164 163          0 163   163  163     255
## 165 164          0 164   164  164     255
## 166 165          0 165   165  165     255
## 167 166          0 166   166  166     255
## 168 167          0 167   167  167     255
## 169 168          0 168   168  168     255
## 170 169          0 169   169  169     255
## 171 170          0 170   170  170     255
## 172 171          0 171   171  171     255
## 173 172          0 172   172  172     255
## 174 173          0 173   173  173     255
```

```
## 175 174           0 174   174  174     255
## 176 175           0 175   175  175     255
## 177 176           0 176   176  176     255
## 178 177           0 177   177  177     255
## 179 178           0 178   178  178     255
## 180 179           0 179   179  179     255
## 181 180           0 180   180  180     255
## 182 181           0 181   181  181     255
## 183 182           0 182   182  182     255
## 184 183           0 183   183  183     255
## 185 184           0 184   184  184     255
## 186 185           0 185   185  185     255
## 187 186           0 186   186  186     255
## 188 187           0 187   187  187     255
## 189 188           0 188   188  188     255
## 190 189           0 189   189  189     255
## 191 190           0 190   190  190     255
## 192 191           0 191   191  191     255
## 193 192           0 192   192  192     255
## 194 193           0 193   193  193     255
## 195 194           0 194   194  194     255
## 196 195           0 195   195  195     255
## 197 196           0 196   196  196     255
## 198 197           0 197   197  197     255
## 199 198           0 198   198  198     255
## 200 199           0 199   199  199     255
## 201 200           0 200   200  200     255
## 202 201           0 201   201  201     255
## 203 202           0 202   202  202     255
## 204 203           0 203   203  203     255
## 205 204           0 204   204  204     255
## 206 205           0 205   205  205     255
## 207 206           0 206   206  206     255
## 208 207           0 207   207  207     255
## 209 208           0 208   208  208     255
## 210 209           0 209   209  209     255
## 211 210           0 210   210  210     255
## 212 211           0 211   211  211     255
## 213 212           0 212   212  212     255
## 214 213           0 213   213  213     255
## 215 214           0 214   214  214     255
## 216 215           0 215   215  215     255
## 217 216           0 216   216  216     255
## 218 217           0 217   217  217     255
## 219 218           0 218   218  218     255
## 220 219           0 219   219  219     255
## 221 220           0 220   220  220     255
## 222 221           0 221   221  221     255
## 223 222           0 222   222  222     255
## 224 223           0 223   223  223     255
## 225 224           0 224   224  224     255
## 226 225           0 225   225  225     255
## 227 226           0 226   226  226     255
## 228 227           0 227   227  227     255
```

```
## 229 228          0 228   228  228     255
## 230 229          0 229   229  229     255
## 231 230          0 230   230  230     255
## 232 231          0 231   231  231     255
## 233 232          0 232   232  232     255
## 234 233          0 233   233  233     255
## 235 234          0 234   234  234     255
## 236 235          0 235   235  235     255
## 237 236          0 236   236  236     255
## 238 237          0 237   237  237     255
## 239 238          0 238   238  238     255
## 240 239          0 239   239  239     255
## 241 240          0 240   240  240     255
## 242 241          0 241   241  241     255
## 243 242          0 242   242  242     255
## 244 243          0 243   243  243     255
## 245 244          0 244   244  244     255
## 246 245          0 245   245  245     255
## 247 246          0 246   246  246     255
## 248 247          0 247   247  247     255
## 249 248          0 248   248  248     255
## 250 249          0 249   249  249     255
## 251 250          0 250   250  250     255
## 252 251          0 251   251  251     255
## 253 252          0 252   252  252     255
## 254 253          0 253   253  253     255
## 255 254          0 254   254  254     255
## 256 255          0 255   255  255     255
##
##
## Slot "haveminmax":
## [1] TRUE
##
## Slot "min":
## [1] 0
##
## Slot "max":
## [1] 95
##
## Slot "band":
## [1] 1
##
## Slot "unit":
## [1] ""
##
## Slot "names":
## [1] "nlcd_2019_land_cover_l48_20210604"
##
##
## $legend
## An object of class ".RasterLegend"
## Slot "type":
## character(0)
##
```

```
## Slot "values":
## logical(0)
##
## Slot "color":
## logical(0)
##
## Slot "names":
## logical(0)
##
## Slot "colortable":
##   [1] "#000000" "#000000" "#000000" "#000000" "#000000" "#000000" "#000000"
##   [8] "#000000" "#000000" "#000000" "#000000" "#466B9F" "#D1DEF8" "#000000"
##  [15] "#000000" "#000000" "#000000" "#000000" "#000000" "#000000" "#000000"
##  [22] "#DEC5C5" "#D99282" "#EB0000" "#AB0000" "#000000" "#000000" "#000000"
##  [29] "#000000" "#000000" "#000000" "#B3AC9F" "#000000" "#000000" "#000000"
##  [36] "#000000" "#000000" "#000000" "#000000" "#000000" "#000000" "#68AB5F"
##  [43] "#1C5F2C" "#B5C58F" "#000000" "#000000" "#000000" "#000000" "#000000"
##  [50] "#000000" "#000000" "#000000" "#CCB879" "#000000" "#000000" "#000000"
##  [57] "#000000" "#000000" "#000000" "#000000" "#000000" "#000000" "#000000"
##  [64] "#000000" "#000000" "#000000" "#000000" "#000000" "#000000" "#000000"
##  [71] "#000000" "#DFDFC2" "#000000" "#000000" "#000000" "#000000" "#000000"
##  [78] "#000000" "#000000" "#000000" "#000000" "#DCD939" "#AB6C28" "#000000"
##  [85] "#000000" "#000000" "#000000" "#000000" "#000000" "#000000" "#B8D9EB"
##  [92] "#000000" "#000000" "#000000" "#000000" "#6C9FB8" "#606060" "#616161"
##  [99] "#626262" "#636363" "#646464" "#656565" "#666666" "#676767" "#686868"
## [106] "#696969" "#6A6A6A" "#6B6B6B" "#6C6C6C" "#6D6D6D" "#6E6E6E" "#6F6F6F"
## [113] "#707070" "#717171" "#727272" "#737373" "#747474" "#757575" "#767676"
## [120] "#777777" "#787878" "#797979" "#7A7A7A" "#7B7B7B" "#7C7C7C" "#7D7D7D"
## [127] "#7E7E7E" "#7F7F7F" "#808080" "#818181" "#828282" "#838383" "#848484"
## [134] "#858585" "#868686" "#878787" "#888888" "#898989" "#8A8A8A" "#8B8B8B"
## [141] "#8C8C8C" "#8D8D8D" "#8E8E8E" "#8F8F8F" "#909090" "#919191" "#929292"
## [148] "#939393" "#949494" "#959595" "#969696" "#979797" "#989898" "#999999"
## [155] "#9A9A9A" "#9B9B9B" "#9C9C9C" "#9D9D9D" "#9E9E9E" "#9F9F9F" "#A0A0A0"
## [162] "#A1A1A1" "#A2A2A2" "#A3A3A3" "#A4A4A4" "#A5A5A5" "#A6A6A6" "#A7A7A7"
## [169] "#A8A8A8" "#A9A9A9" "#AAAAAA" "#ABABAB" "#ACACAC" "#ADADAD" "#AEAEAE"
## [176] "#AFAFAF" "#B0B0B0" "#B1B1B1" "#B2B2B2" "#B3B3B3" "#B4B4B4" "#B5B5B5"
## [183] "#B6B6B6" "#B7B7B7" "#B8B8B8" "#B9B9B9" "#BABABA" "#BBBBBB" "#BCBCBC"
## [190] "#BDBDBD" "#BEBEBE" "#BFBFBF" "#C0C0C0" "#C1C1C1" "#C2C2C2" "#C3C3C3"
## [197] "#C4C4C4" "#C5C5C5" "#C6C6C6" "#C7C7C7" "#C8C8C8" "#C9C9C9" "#CACACA"
## [204] "#CBCBCB" "#CCCCCC" "#CDCDCD" "#CECECE" "#CFCFCF" "#D0D0D0" "#D1D1D1"
## [211] "#D2D2D2" "#D3D3D3" "#D4D4D4" "#D5D5D5" "#D6D6D6" "#D7D7D7" "#D8D8D8"
## [218] "#D9D9D9" "#DADADA" "#DBDBDB" "#DCDCDC" "#DDDDDD" "#DEDEDE" "#DFDFDF"
## [225] "#E0E0E0" "#E1E1E1" "#E2E2E2" "#E3E3E3" "#E4E4E4" "#E5E5E5" "#E6E6E6"
## [232] "#E7E7E7" "#E8E8E8" "#E9E9E9" "#EAEAEA" "#EBEBEB" "#ECECEC" "#EDEDED"
## [239] "#EEEEEE" "#EFEFEF" "#F0F0F0" "#F1F1F1" "#F2F2F2" "#F3F3F3" "#F4F4F4"
## [246] "#F5F5F5" "#F6F6F6" "#F7F7F7" "#F8F8F8" "#F9F9F9" "#FAFAFA" "#FBFBFB"
## [253] "#FCFCFC" "#FDFDFD" "#FEFEFE" "#FFFFFF"
##
##
## $title
## character(0)
##
## $extent
## class      : Extent
```

```
## xmin       : -2493045
## xmax       : 2342655
## ymin       : 177285
## ymax       : 3310005
##
## $rotated
## [1] FALSE
##
## $rotation
## An object of class ".Rotation"
## Slot "geotrans":
## numeric(0)
##
## Slot "transfun":
## function ()
## NULL
## <bytecode: 0x0000000019429c58>
##
##
## $ncols
## [1] 161190
##
## $nrows
## [1] 104424
##
## $crs
## CRS arguments:
##  +proj=aea +lat_0=23 +lon_0=-96 +lat_1=29.5 +lat_2=45.5 +x_0=0 +y_0=0
## +datum=WGS84 +units=m +no_defs
##
## $history
## list()
##
## $z
## list()
##
## $class
## [1] "RasterLayer"
## attr(,"package")
## [1] "raster"
```

```
land_class_table <- data.table(attributes(nlcd_R)$data@attributes[[1]])
land_class_table$NLCD.Land.Cover.Class %>% unique()
```

```
##  [1] Unclassified
##  [3] Open Water                   Perennial Snow/Ice
##  [5] Developed, Open Space        Developed, Low Intensity
##  [7] Developed, Medium Intensity  Developed, High Intensity
##  [9] Barren Land                  Deciduous Forest
## [11] Evergreen Forest             Mixed Forest
## [13] Shrub/Scrub                  Herbaceous
## [15] Hay/Pasture                  Cultivated Crops
## [17] Woody Wetlands               Emergent Herbaceous Wetlands
## 18 Levels:  Barren Land Cultivated Crops ... Woody Wetlands
```

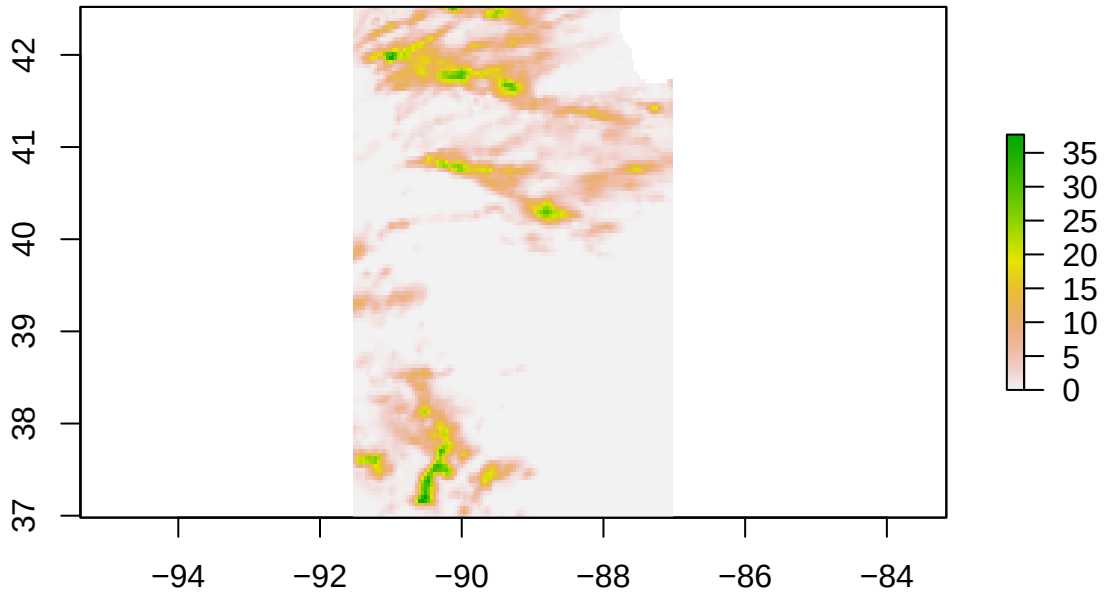
```
land_class_table[NLCD.Land.Cover.Class %in% c("Hay/Pasture", "Cultivated Crops")]
```

```
##    ID      COUNT Red Green Blue Opacity NLCD.Land.Cover.Class
## 1: 81  560647664 220   217   57     255           Hay/Pasture
## 2: 82 1464715609 171   108   40     255      Cultivated Crops
```

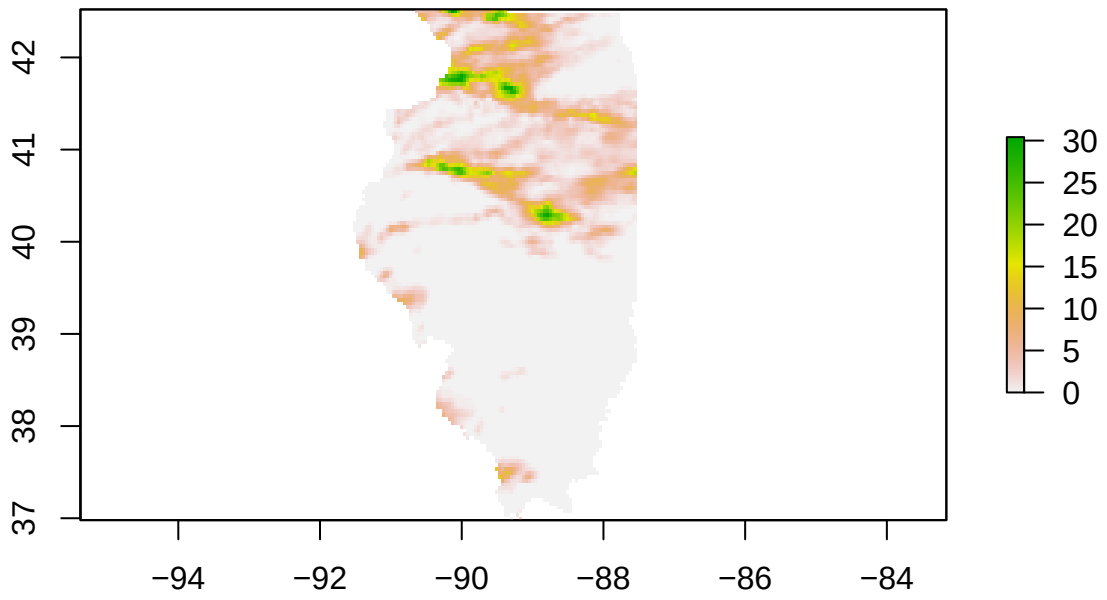
1.4 Polygonize the PRISM grid for the study area

```
prism_R <- prism_S[[1]]

prism_R <- crop(prism_R, st_transform(il_cb, crs(prism_R)))
plot(prism_R)
```




```
prism_R <- mask(prism_R, st_transform(il_cb, crs(prism_R)))
plot(prism_R)
```




```
prism_R
```

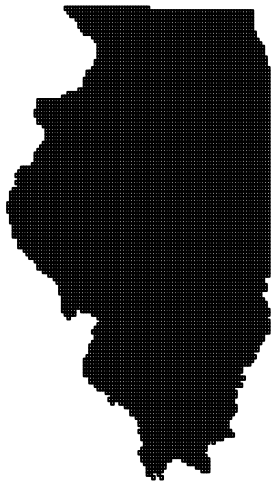
```
## class      : RasterLayer
## dimensions : 133, 108, 14364  (nrow, ncol, ncell)
## resolution : 0.04166667, 0.04166667  (x, y)
## extent     : -91.52083, -87.02083, 36.97917, 42.52083  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=NAD83 +no_defs
## source     : memory
## names      : PRISM_ppt_stable_4kmD2_20190710_bil
## values     : 0, 30.414  (min, max)
```

```
prism_P <- rasterToPolygons(prism_R)
prism_P <- st_as_sf(prism_P)
prism_P
```

```
## Simple feature collection with 8903 features and 1 field
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: -91.52083 ymin: 36.97917 xmax: -87.52083 ymax: 42.52083
## Geodetic CRS:  NAD83
## First 10 features:
##    PRISM_ppt_stable_4kmD2_20190710_bil                       geometry
## 1                                3.535 POLYGON ((-90.64583 42.5208...
## 2                                3.441 POLYGON ((-90.60417 42.5208...
## 3                                4.173 POLYGON ((-90.5625 42.52083...
```

```
## 4                                4.782 POLYGON ((-90.52083 42.5208...
## 5                                4.875 POLYGON ((-90.47917 42.5208...
## 6                                4.390 POLYGON ((-90.4375 42.52083...
## 7                                4.274 POLYGON ((-90.39583 42.5208...
## 8                                5.768 POLYGON ((-90.35417 42.5208...
## 9                                9.413 POLYGON ((-90.3125 42.52083...
## 10                              14.148 POLYGON ((-90.27083 42.5208...
```

```
plot(prism_P[, "geometry"])
```



1.5 Extract land cover values for each PRISM cell

```
prism_P$nlcd <- exactextractr::exact_extract(nlcd_R, prism_P)
```

```
sapply(prism_P, class)
```

```
## $PRISM_ppt_stable_4kmD2_20190710_bil
## [1] "numeric"
##
## $geometry
## [1] "sfc_POLYGON" "sfc"
##
## $nlcd
## [1] "list"
```

```
dim(prism_P$nlcd[[1]])
```

```
## [1] 17898     2
```

```
prism_P$nlcd[[1]][1:5, ]
```

```
##   value coverage_fraction
## 1    23        0.02295327
## 2    23        0.07929222
## 3    22        0.13591179
## 4    81        0.19253136
## 5    81        0.24915093
```

1.6 Sum coverage fraction by land cover type for each PRISM cell

```
plan(multisession)
prism_P$n_by_type <- future_map(prism_P$nlcd,
  function(x) {
    data.table(x)[, .(n = sum(coverage_fraction)), value]
  },
  .progress = T
)

prism_P$n_by_type[[1]]
```

```
##     value         n
##  1:    23 1257.5283
##  2:    22 1804.0329
##  3:    81 2668.3661
##  4:    21 2498.7162
##  5:    24  364.8477
##  6:    41 3269.6139
##  7:    82 2090.2709
##  8:    43  935.5375
##  9:    11 1704.5097
## 10:    90  601.3428
## 11:    95  208.0005
## 12:    71   14.0000
## 13:    52  157.8763
## 14:    42   37.0000
## 15:    31    2.0000
```

1.7 Calculate the fraction of cropland for each PRISM cell

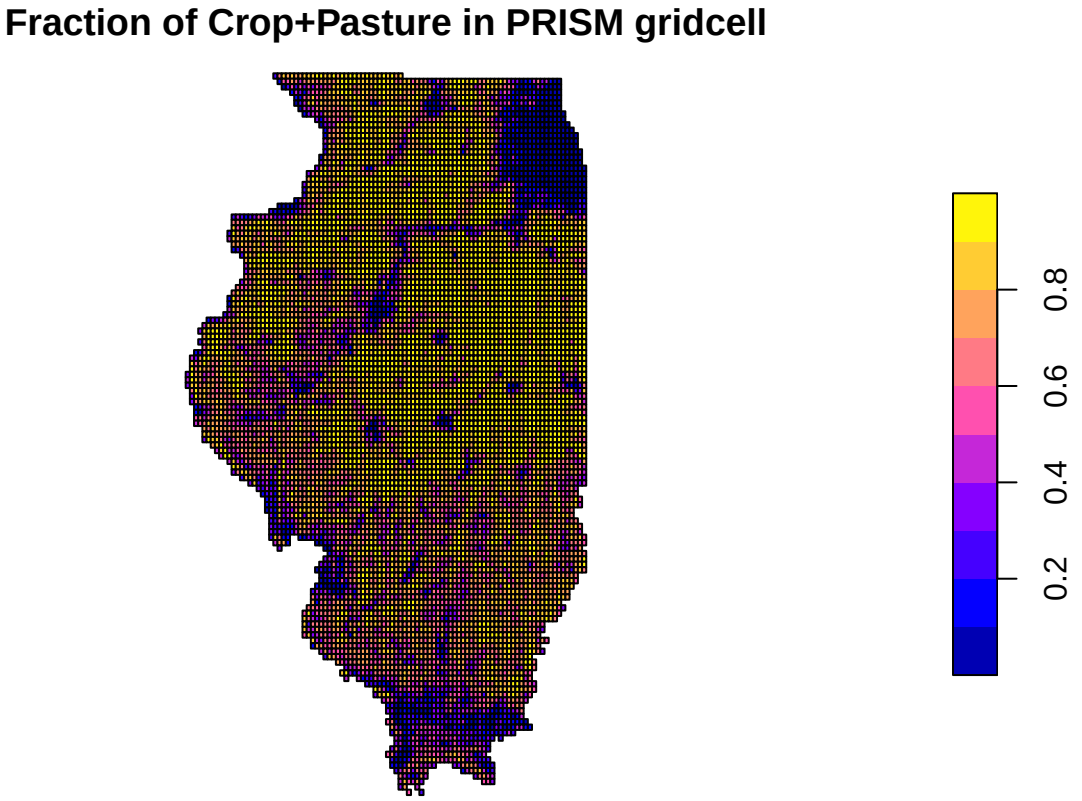
```
prism_P$fraction <- map_dbl(
  prism_P$n_by_type,
  function(x) {
    x[, sum(n[value %in% c(81, 82)]) / sum(n)]
```

```
  }
)
```

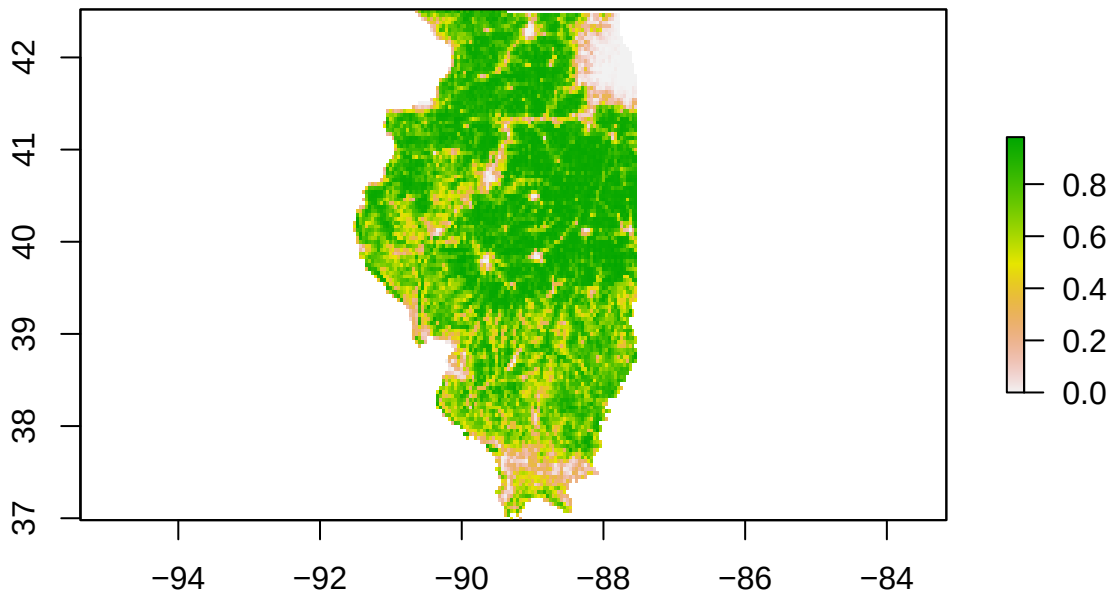
1.8 Rasterize

```
il_crop_R <- rasterize(prism_P, prism_R, "fraction")
```

```
plot(prism_P[, "fraction"], main="Fraction of Crop+Pasture in PRISM gridcell")
```




```
plot(il_crop_R)
```



2 Calculating county-level temperatures

```
prism_S <- mask(prism_S, prism_P)


il_prism <-
  cbind(il_cb[,"GEOID"],
        exactextractr::exact_extract(prism_S,
                                     il_cb,
                                     "weighted_mean",
                                     weights = il_crop_R,
                                     stack_apply = T))
```

```
names(il_prism)
```

```
##  [1] "GEOID"
##  [2] "weighted_mean.PRISM_ppt_stable_4kmD2_20190710_bil"
##  [3] "weighted_mean.PRISM_ppt_stable_4kmD2_20190711_bil"
##  [4] "weighted_mean.PRISM_ppt_stable_4kmD2_20190712_bil"
##  [5] "weighted_mean.PRISM_ppt_stable_4kmD2_20190713_bil"
##  [6] "weighted_mean.PRISM_ppt_stable_4kmD2_20190714_bil"
##  [7] "weighted_mean.PRISM_ppt_stable_4kmD2_20190715_bil"
```

```
##  [8] "weighted_mean.PRISM_ppt_stable_4kmD2_20190716_bil"
##  [9] "weighted_mean.PRISM_ppt_stable_4kmD2_20190717_bil"
## [10] "weighted_mean.PRISM_ppt_stable_4kmD2_20190718_bil"
## [11] "weighted_mean.PRISM_ppt_stable_4kmD2_20190719_bil"
## [12] "weighted_mean.PRISM_tmax_stable_4kmD2_20190710_bil"
## [13] "weighted_mean.PRISM_tmax_stable_4kmD2_20190711_bil"
## [14] "weighted_mean.PRISM_tmax_stable_4kmD2_20190712_bil"
## [15] "weighted_mean.PRISM_tmax_stable_4kmD2_20190713_bil"
## [16] "weighted_mean.PRISM_tmax_stable_4kmD2_20190714_bil"
## [17] "weighted_mean.PRISM_tmax_stable_4kmD2_20190715_bil"
## [18] "weighted_mean.PRISM_tmax_stable_4kmD2_20190716_bil"
## [19] "weighted_mean.PRISM_tmax_stable_4kmD2_20190717_bil"
## [20] "weighted_mean.PRISM_tmax_stable_4kmD2_20190718_bil"
## [21] "weighted_mean.PRISM_tmax_stable_4kmD2_20190719_bil"
## [22] "weighted_mean.PRISM_tmin_stable_4kmD2_20190710_bil"
## [23] "weighted_mean.PRISM_tmin_stable_4kmD2_20190711_bil"
## [24] "weighted_mean.PRISM_tmin_stable_4kmD2_20190712_bil"
## [25] "weighted_mean.PRISM_tmin_stable_4kmD2_20190713_bil"
## [26] "weighted_mean.PRISM_tmin_stable_4kmD2_20190714_bil"
## [27] "weighted_mean.PRISM_tmin_stable_4kmD2_20190715_bil"
## [28] "weighted_mean.PRISM_tmin_stable_4kmD2_20190716_bil"
## [29] "weighted_mean.PRISM_tmin_stable_4kmD2_20190717_bil"
## [30] "weighted_mean.PRISM_tmin_stable_4kmD2_20190718_bil"
## [31] "weighted_mean.PRISM_tmin_stable_4kmD2_20190719_bil"
## [32] "geometry"
```

```
df_prism <- il_prism %>%
  st_drop_geometry() %>%
  pivot_longer(!"GEOID") %>%
  mutate(
    var = str_extract(name, "tmax|tmin"),
    date = str_extract(name, "[0-9]{8}"),
    year = as.integer(str_sub(date, 1, 4)),
    month = as.integer(str_sub(date, 5, 6)),
    day = as.integer(str_sub(date, 7, 8))
  ) %>%
  dplyr::select(-c("name", "date")) %>%
  drop_na() %>%
  spread(var, value) %>%
  mutate(dday30 = pmap_dbl(
    list(tmin, tmax),
    function(tmin, tmax) {
      degree_days(tmin, tmax, 30, 100)
    }
  ))


df_prism
```

```
## # A tibble: 1,020 x 7
##    GEOID  year month   day  tmax  tmin dday30
##    <chr> <int> <int> <int> <dbl> <dbl>  <dbl>
##  1 17001  2019     7    10  32.0  22.7 0.399
##  2 17001  2019     7    11  33.5  19.8 0.776
```

```
##  3 17001  2019     7    12  29.0  18.8 0
##  4 17001  2019     7    13  30.6  19.4 0.0660
##  5 17001  2019     7    14  32.6  21.1 0.536
##  6 17001  2019     7    15  32.7  20.2 0.553
##  7 17001  2019     7    16  28.4  21.2 0
##  8 17001  2019     7    17  29.4  21.5 0
##  9 17001  2019     7    18  32.8  20.7 0.600
## 10 17001  2019     7    19  33.6  24.0 0.982
## # ... with 1,010 more rows
```