

# Applied Economics Research using R: Session 2

## Geospatial Data for Applied Economics

Seunghyun Lee ([arslee@ucdavis.edu](mailto:arslee@ucdavis.edu))

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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 geospatial 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.

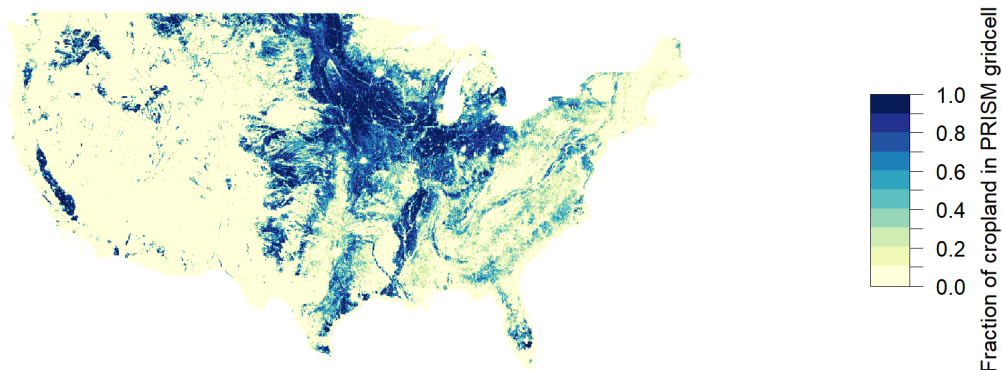
The scripts below generalize the small pieces included in this document to create the daily county-level weather data in 2019 and 2020 for all the counties in the Contiguous US. Constructed weather variables include precipitation, and degree days above 0, 5, 8, 10, 12, 15, 20, 25, 29, 30, 31, 32, 33 and 34 degree Celsius. Note that in the last two scripts I use `data.table` more extensively than in the class. `data.table` is powerful when dealing with a large dataset.

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

```
## [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"
## [4] "140_compare WS vs SL.R"
```

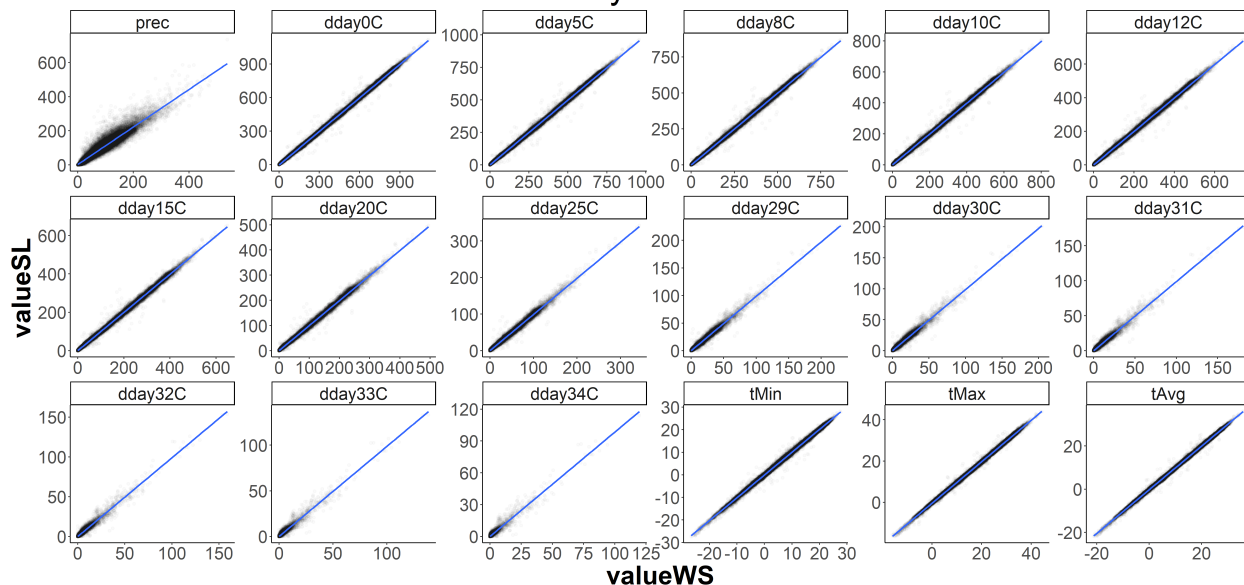
The figure below shows spatial variation in the share of cropland (cultivated crop + hay/pasture from NLCD 2019) on the PRISM grids across the US.

**Fraction of crop + pasture land in PRISM gridcell**



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.

**WS vs SL: Monthly Weather Data for 2019**



## 1 Aggregate land cover to the PRISM grid

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

```
## |
```

```
|
```

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

```
## [1] "Data/Raw/prism//PRISM_ppt_stable_4kmD2_20190710_bil/PRISM_ppt_stable_4kmD2_20190710_bil.bil"  
## [2] "Data/Raw/prism//PRISM_ppt_stable_4kmD2_20190711_bil/PRISM_ppt_stable_4kmD2_20190711_bil.bil"  
## [3] "Data/Raw/prism//PRISM_ppt_stable_4kmD2_20190712_bil/PRISM_ppt_stable_4kmD2_20190712_bil.bil"  
## [4] "Data/Raw/prism//PRISM_ppt_stable_4kmD2_20190713_bil/PRISM_ppt_stable_4kmD2_20190713_bil.bil"  
## [5] "Data/Raw/prism//PRISM_ppt_stable_4kmD2_20190714_bil/PRISM_ppt_stable_4kmD2_20190714_bil.bil"  
## [6] "Data/Raw/prism//PRISM_ppt_stable_4kmD2_20190715_bil/PRISM_ppt_stable_4kmD2_20190715_bil.bil"  
## [7] "Data/Raw/prism//PRISM_ppt_stable_4kmD2_20190716_bil/PRISM_ppt_stable_4kmD2_20190716_bil.bil"  
## [8] "Data/Raw/prism//PRISM_ppt_stable_4kmD2_20190717_bil/PRISM_ppt_stable_4kmD2_20190717_bil.bil"  
## [9] "Data/Raw/prism//PRISM_ppt_stable_4kmD2_20190718_bil/PRISM_ppt_stable_4kmD2_20190718_bil.bil"  
## [10] "Data/Raw/prism//PRISM_ppt_stable_4kmD2_20190719_bil/PRISM_ppt_stable_4kmD2_20190719_bil.bil"  
## [11] "Data/Raw/prism//PRISM_tmax_stable_4kmD2_20190710_bil/PRISM_tmax_stable_4kmD2_20190710_bil.bil"  
## [12] "Data/Raw/prism//PRISM_tmax_stable_4kmD2_20190711_bil/PRISM_tmax_stable_4kmD2_20190711_bil.bil"  
## [13] "Data/Raw/prism//PRISM_tmax_stable_4kmD2_20190712_bil/PRISM_tmax_stable_4kmD2_20190712_bil.bil"  
## [14] "Data/Raw/prism//PRISM_tmax_stable_4kmD2_20190713_bil/PRISM_tmax_stable_4kmD2_20190713_bil.bil"  
## [15] "Data/Raw/prism//PRISM_tmax_stable_4kmD2_20190714_bil/PRISM_tmax_stable_4kmD2_20190714_bil.bil"  
## [16] "Data/Raw/prism//PRISM_tmax_stable_4kmD2_20190715_bil/PRISM_tmax_stable_4kmD2_20190715_bil.bil"  
## [17] "Data/Raw/prism//PRISM_tmax_stable_4kmD2_20190716_bil/PRISM_tmax_stable_4kmD2_20190716_bil.bil"  
## [18] "Data/Raw/prism//PRISM_tmax_stable_4kmD2_20190717_bil/PRISM_tmax_stable_4kmD2_20190717_bil.bil"  
## [19] "Data/Raw/prism//PRISM_tmax_stable_4kmD2_20190718_bil/PRISM_tmax_stable_4kmD2_20190718_bil.bil"  
## [20] "Data/Raw/prism//PRISM_tmax_stable_4kmD2_20190719_bil/PRISM_tmax_stable_4kmD2_20190719_bil.bil"  
## [21] "Data/Raw/prism//PRISM_tmin_stable_4kmD2_20190710_bil/PRISM_tmin_stable_4kmD2_20190710_bil.bil"  
## [22] "Data/Raw/prism//PRISM_tmin_stable_4kmD2_20190711_bil/PRISM_tmin_stable_4kmD2_20190711_bil.bil"  
## [23] "Data/Raw/prism//PRISM_tmin_stable_4kmD2_20190712_bil/PRISM_tmin_stable_4kmD2_20190712_bil.bil"  
## [24] "Data/Raw/prism//PRISM_tmin_stable_4kmD2_20190713_bil/PRISM_tmin_stable_4kmD2_20190713_bil.bil"  
## [25] "Data/Raw/prism//PRISM_tmin_stable_4kmD2_20190714_bil/PRISM_tmin_stable_4kmD2_20190714_bil.bil"  
## [26] "Data/Raw/prism//PRISM_tmin_stable_4kmD2_20190715_bil/PRISM_tmin_stable_4kmD2_20190715_bil.bil"  
## [27] "Data/Raw/prism//PRISM_tmin_stable_4kmD2_20190716_bil/PRISM_tmin_stable_4kmD2_20190716_bil.bil"  
## [28] "Data/Raw/prism//PRISM_tmin_stable_4kmD2_20190717_bil/PRISM_tmin_stable_4kmD2_20190717_bil.bil"  
## [29] "Data/Raw/prism//PRISM_tmin_stable_4kmD2_20190718_bil/PRISM_tmin_stable_4kmD2_20190718_bil.bil"  
## [30] "Data/Raw/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	FUNCTSTAT	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

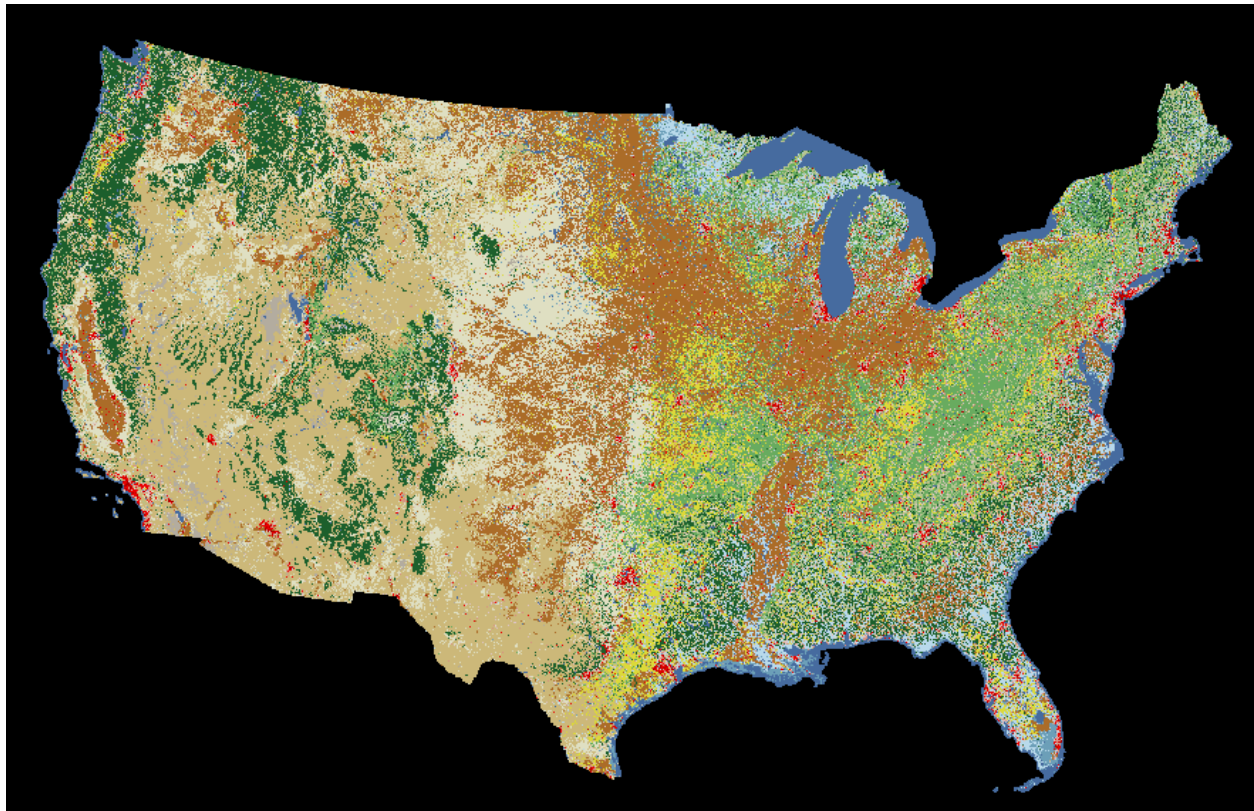
```
nlcd_R <- raster("Data/Raw/nlcd_2019_land_cover_l48_20210604/nlcd_2019_land_cover_l48_20210604.img")

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 +unit=
## 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\\Raw\\nlcd_2019_land_
##
## 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_148_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" "#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: 0x0000000029ef2998>
##
##
## $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

```



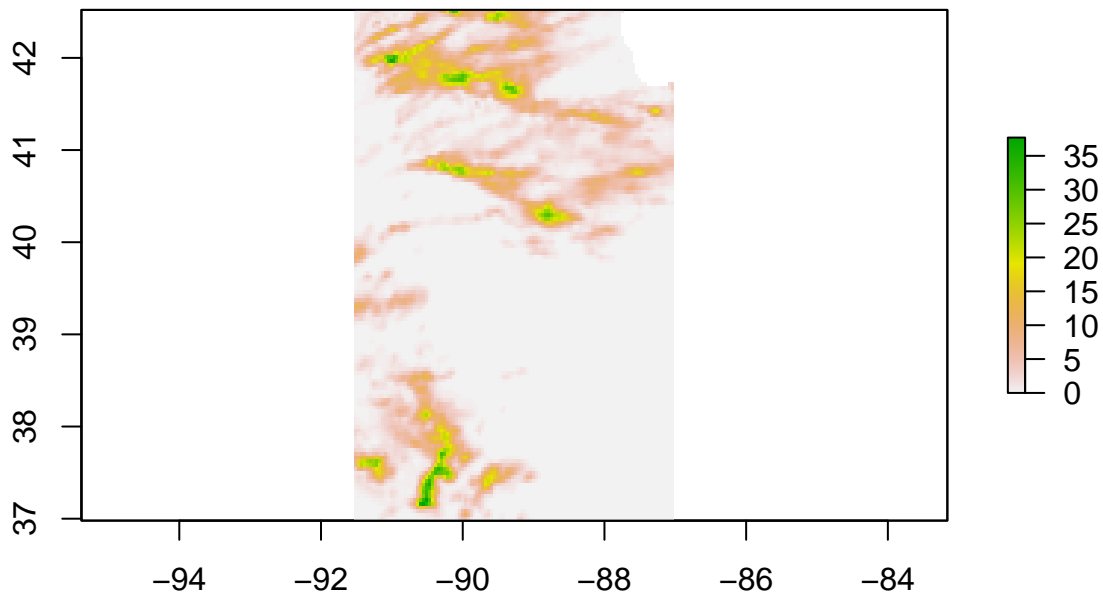
```
land_class_table[NLCD.Land.Cover.Class %in% c("Hay/Pasture", "Cultivated Crops")]
```

```
##      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
```

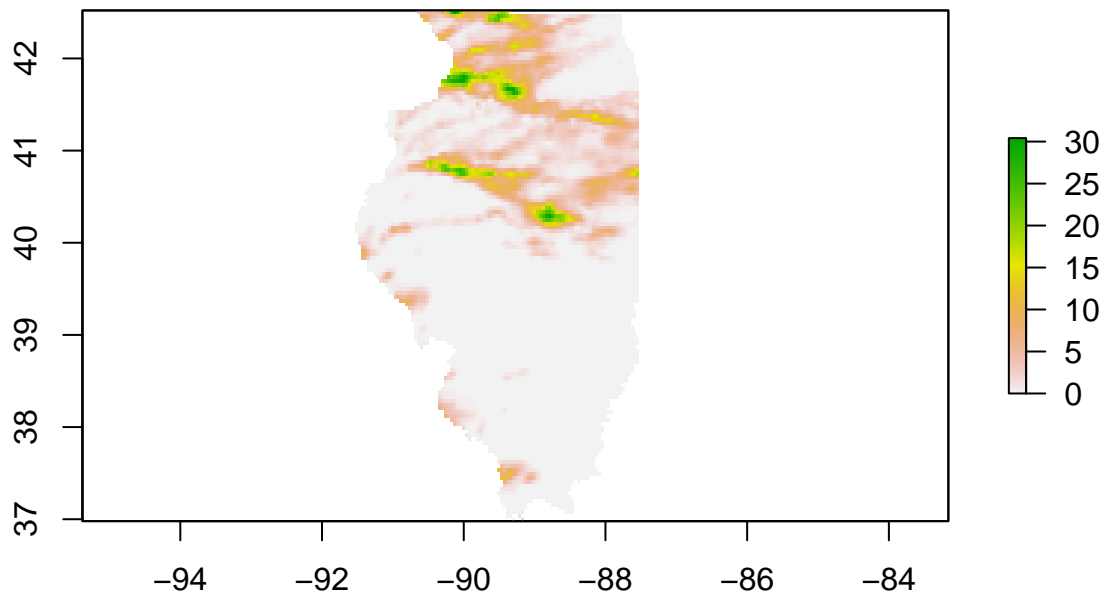
#### 1.4 Polygonize the PRISM grid for the study area

```
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
```

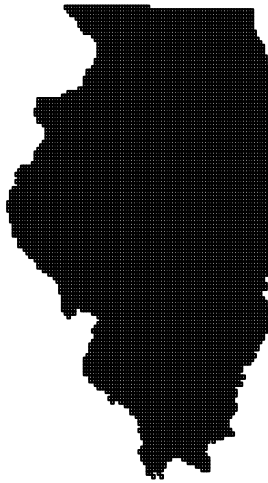
```
## class      : RasterLayer
## dimensions  : 133, 108, 14364  (nrow, ncol, ncell)
## resolution  : 0.04166667, 0.04166667  (x, y)
## extent     : -91.52083, -87.02083, 36.97917, 42.52083  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=NAD83 +no_defs
## source     : memory
## names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

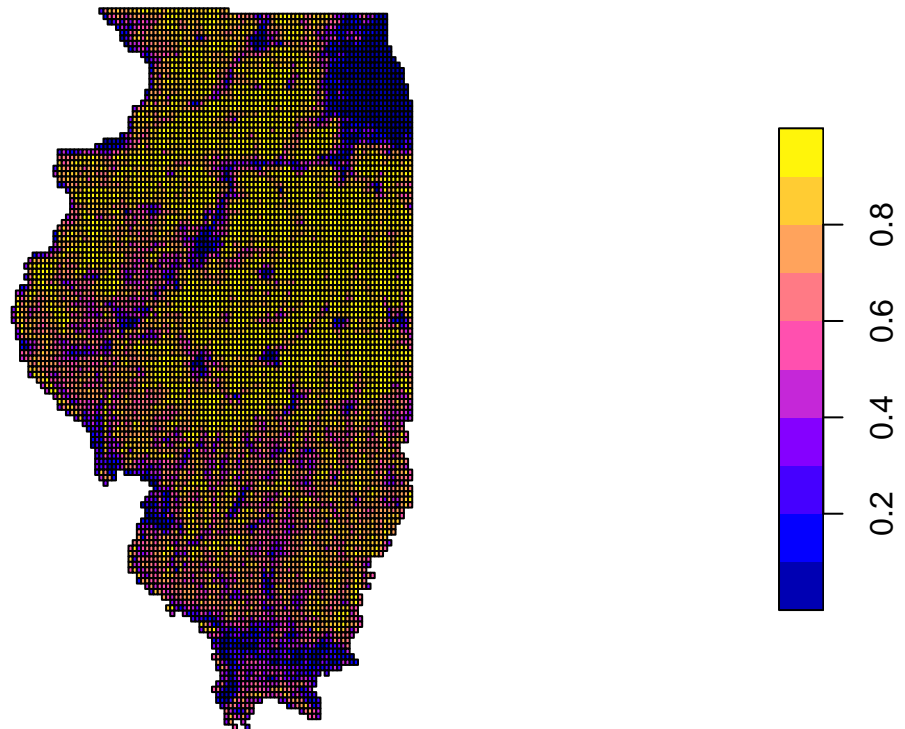
```
}  
)
```

## 1.8 Rasterize

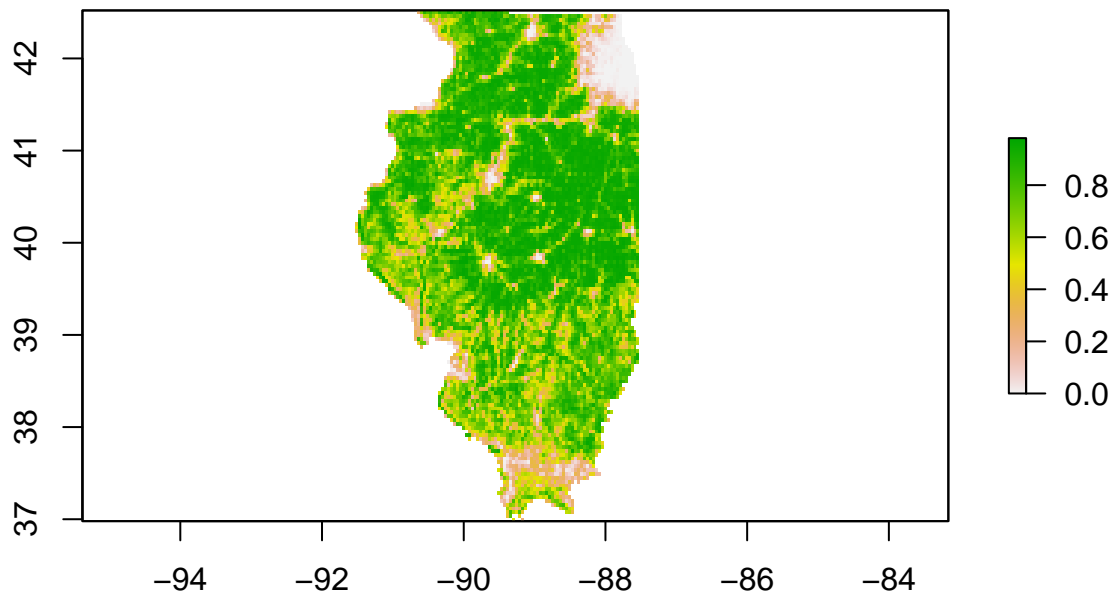
```
il_crop_R <- rasterize(prism_P, prism_R, "fraction")
```

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

### Fraction of Crop+Pasture in PRISM gridcell



```
plot(il_crop_R)
```



## 2 Calculate 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"
```

### 3 Clean data + Calculate degree days above 30C

```
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
```