

CHANGE IN POPULATION DENSITY & DISTRIBUTION IN BEND, OREGON

Dasymetric Mapping, 1990-2000

Bend, Oregon

- Largest city in Oregon east of the Cascade Mountains
- Seventh largest city in Oregon
- Population jump between 1990 & 2000:
20,469 to 52,800 (some of this due to growth, some to expansion of UGB)
- 2009 estimated population: 82,280
- Bend proper covers approximately 32 square miles
- Many jobs tied to real estate and construction since the population boom that took shape in the 1990s – much of which has now dried up
- (Source: City of Bend Website)

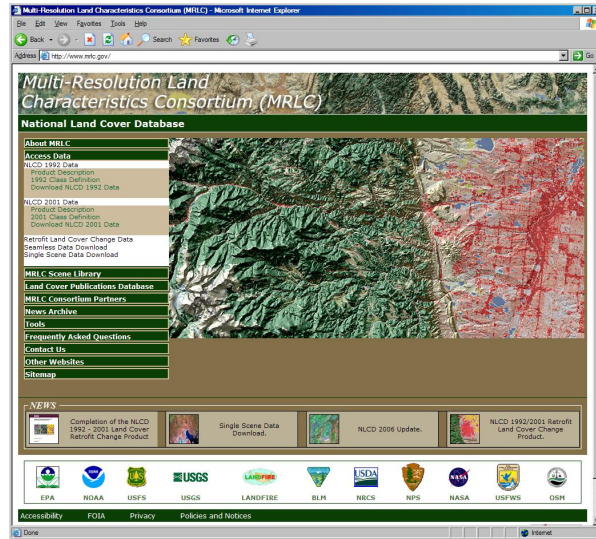
Dasymetric Mapping Review

- A method for disaggregating aggregate data
- Not 100% reliable, but provides a general idea of population concentrations within polygons that show aggregate data
- Uses land cover information to open possibilities of how population is structured within polygons
- Uses mapping units (raster pixels) to represent data in enumeration units (polygons)
- (Source: Readings, lectures)

Dasymetric Mapping of Bend Population Density Change, 1990-2000

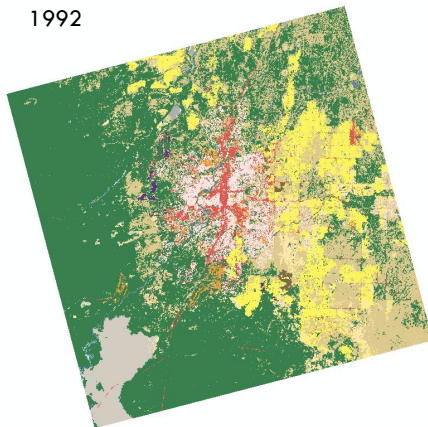
- Data collection
 - Land Cover Data
 - Multi-Resolution Land Characteristics Consortium (MRLC), part of USGS
 - Same land cover data used in Lab 4
 - Census Data
 - Oregon Geospatial Data Library
 - Whole feature classes for 2000
 - Whole feature classes for 1990, via 1995 shapefiles

Land Cover Data

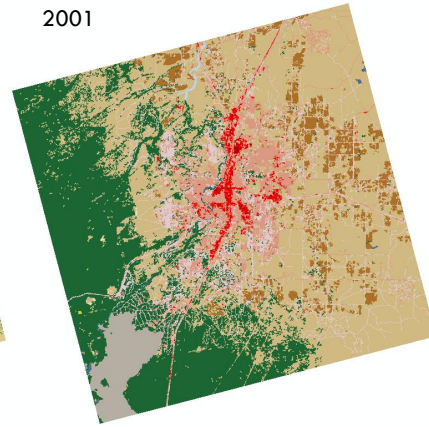


Landcover Rasters from MRLC

1992



2001



What do you notice right away?

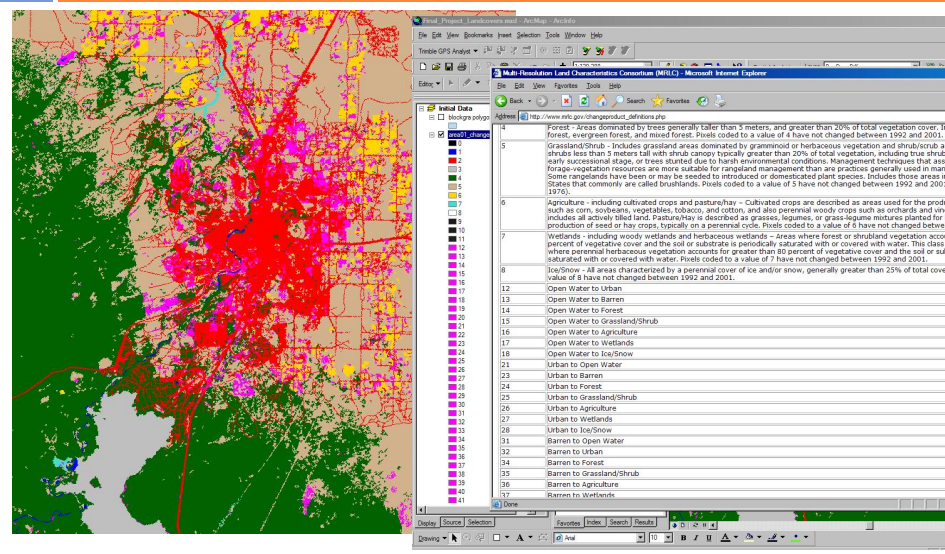
Raster Differences

- Should I directly compare land cover from NLCD 92 with land cover from NLCD 2001?

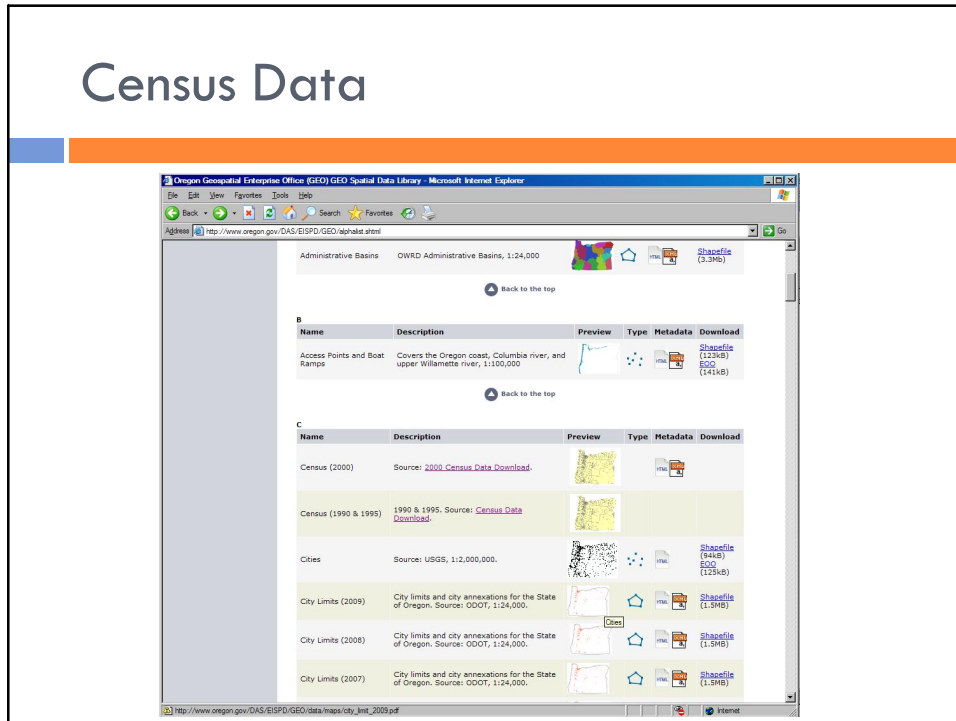
Direct comparison is not recommended. Each dataset was mapped with different methods and slightly different classes. While the two NLCD products are designed to be similar, the slight differences in classification, combined with the final accuracy of the mapping (from 70-80%), result in two distinct products. The typical result of direct comparison will result in a change map showing differences between mapping methods rather than real change on the ground. The NLCD mapping team has completed a product that highlights areas of potential change between the two eras of land cover using the original TM imagery. This product is available for download at the MRLC web site. Access the [Retrofit Land Cover Change Data product](#).

- From: <http://www.mrlc.gov/faq.php>

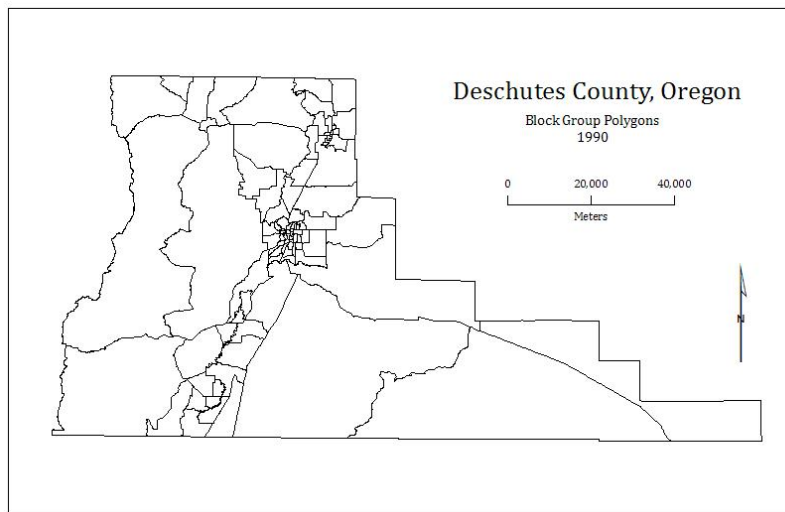
Retrofit Land Cover Change Data product



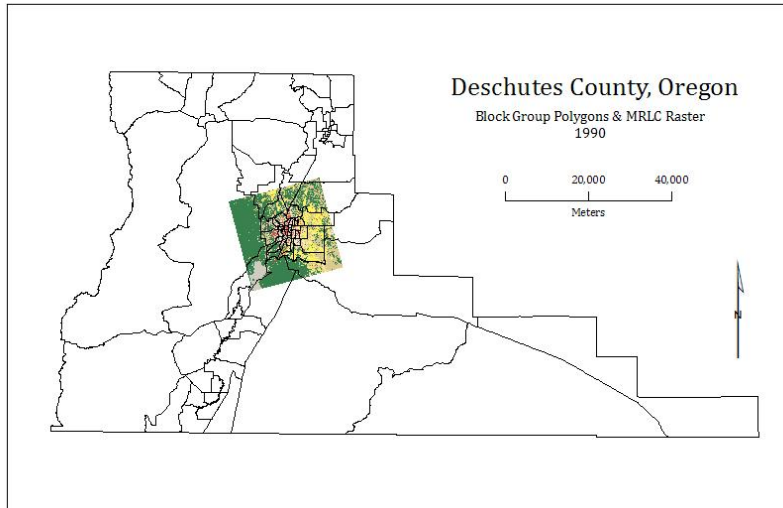
Census Data



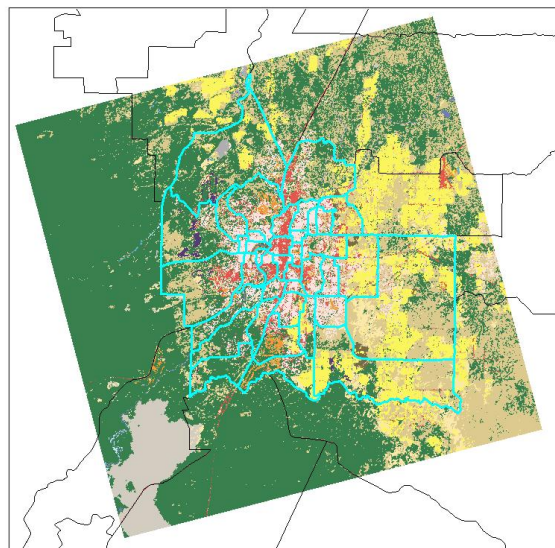
Deschutes County Block Groups, 1990



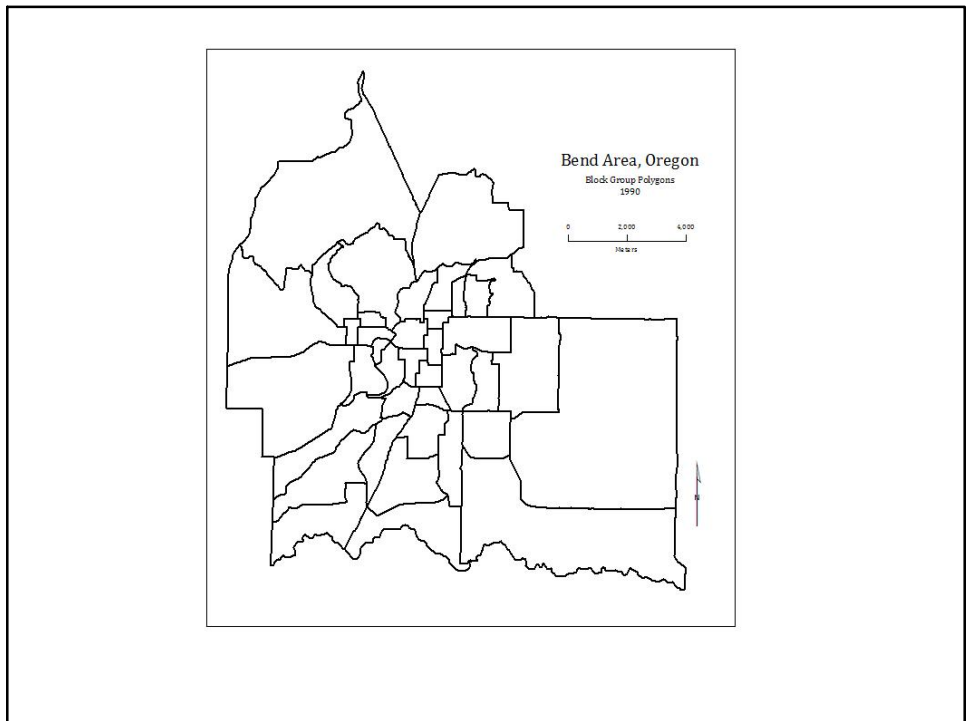
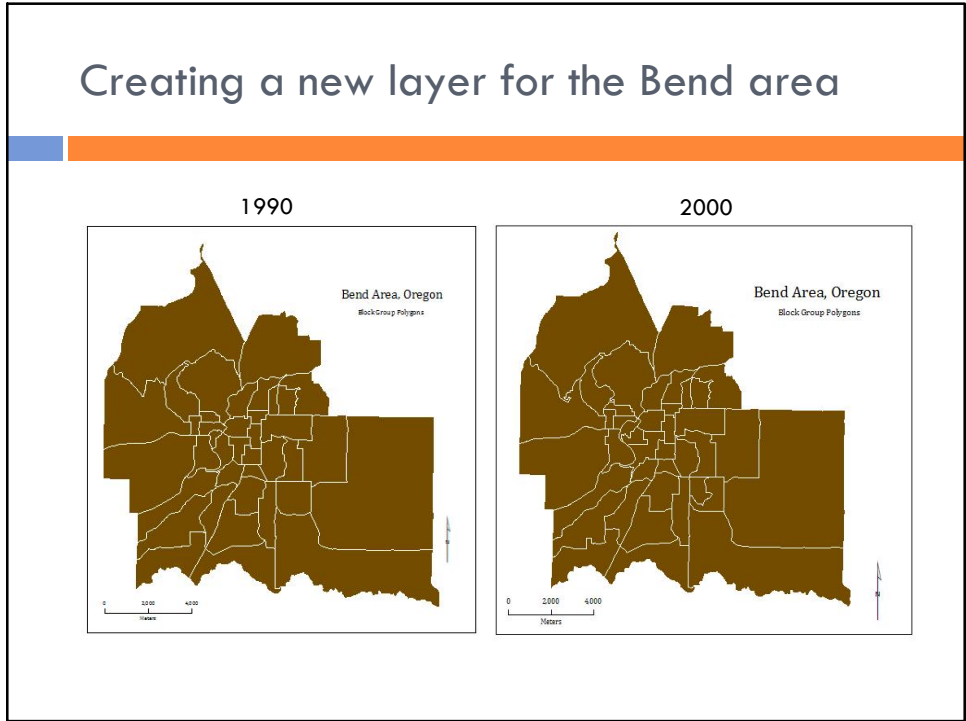
Choosing Block Groups for Study

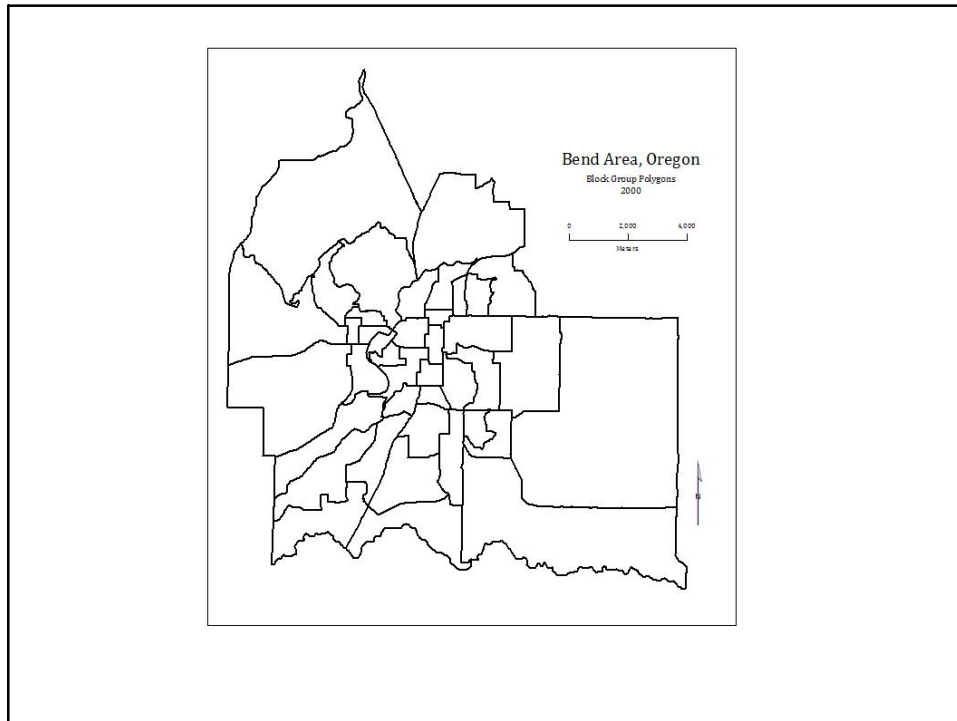


Choosing Block Groups for Study

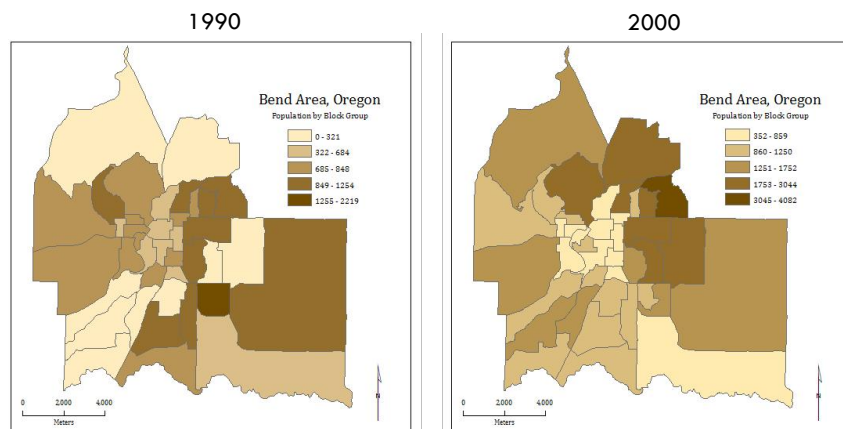


Creating a new layer for the Bend area

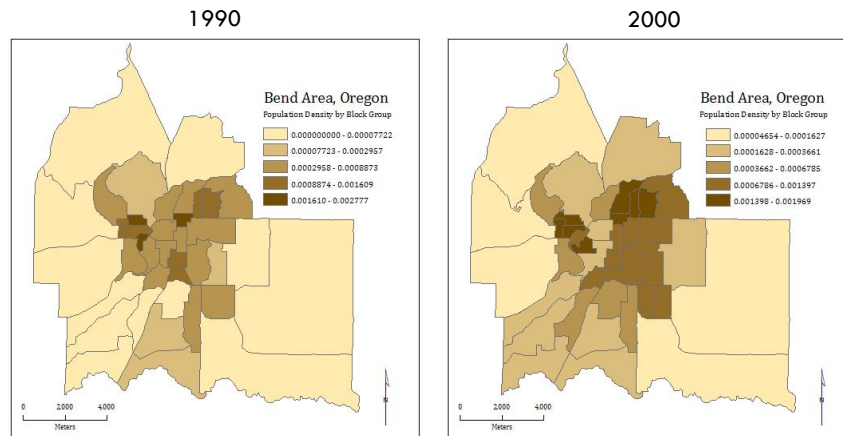




Population (Choropleth by Block Group)



Population Density (Choropleth by Block Group)



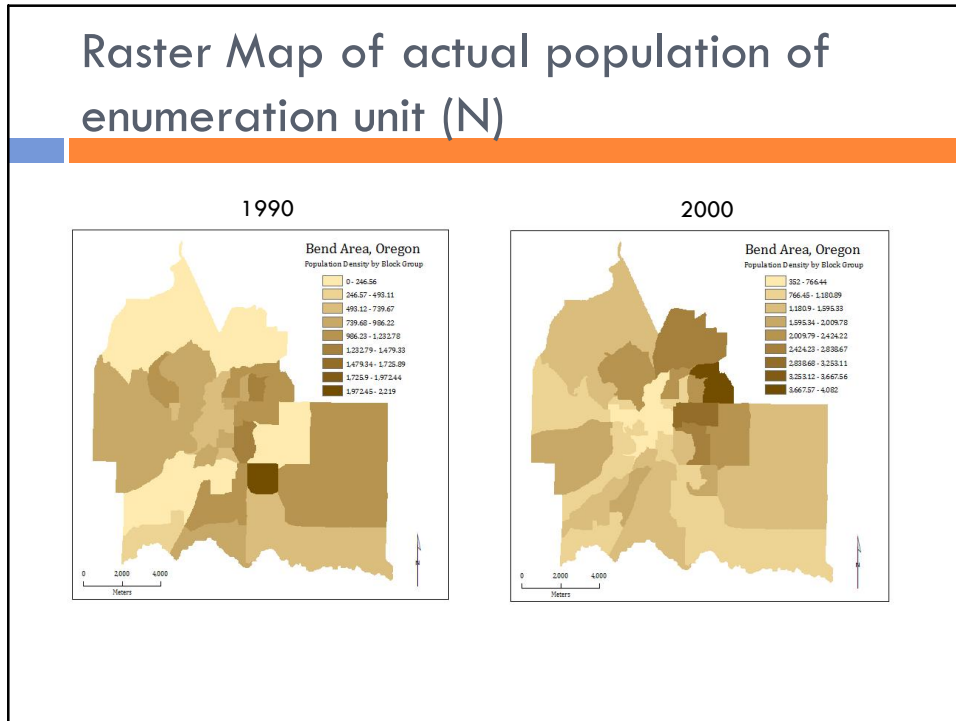
Calculation of Population per Landcover Raster Cell

□ Directly from Lab 4:

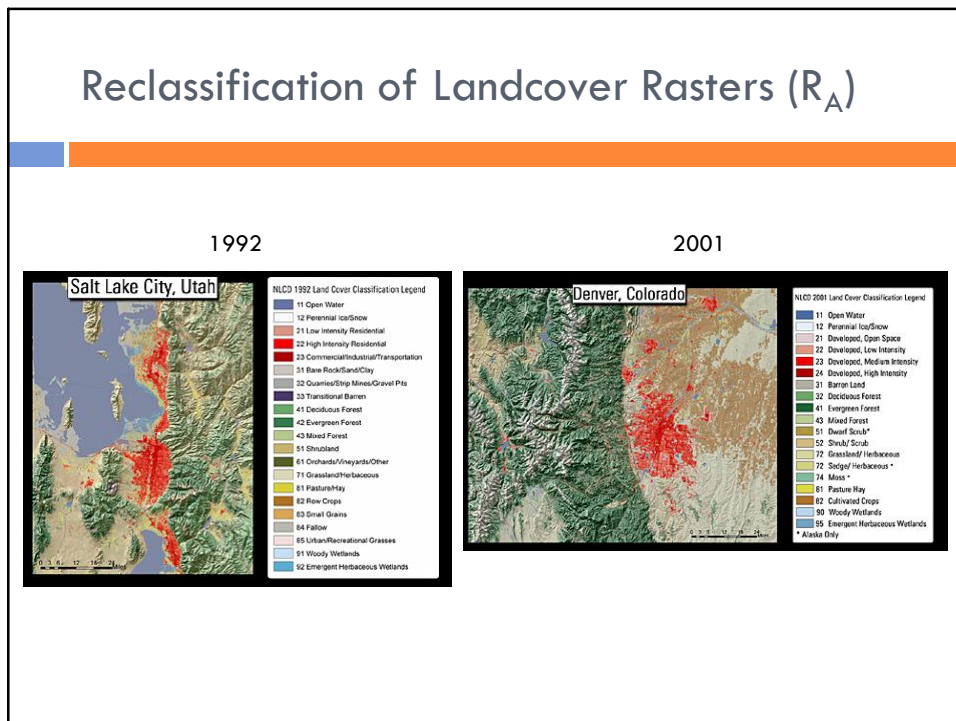
$$□ P = \{[R_A * (P_A / P_A)] * N / E\} / A_T$$

- P = population of cell
- R_A = relative density of the cell with landcover type A
- P_A = proportion of cells of landcover type A in enumeration unit
- N = actual population of enumeration unit
- E = expected population of enumeration unit calculated using the relative densities
- A_T = total number of cells in the enumeration unit

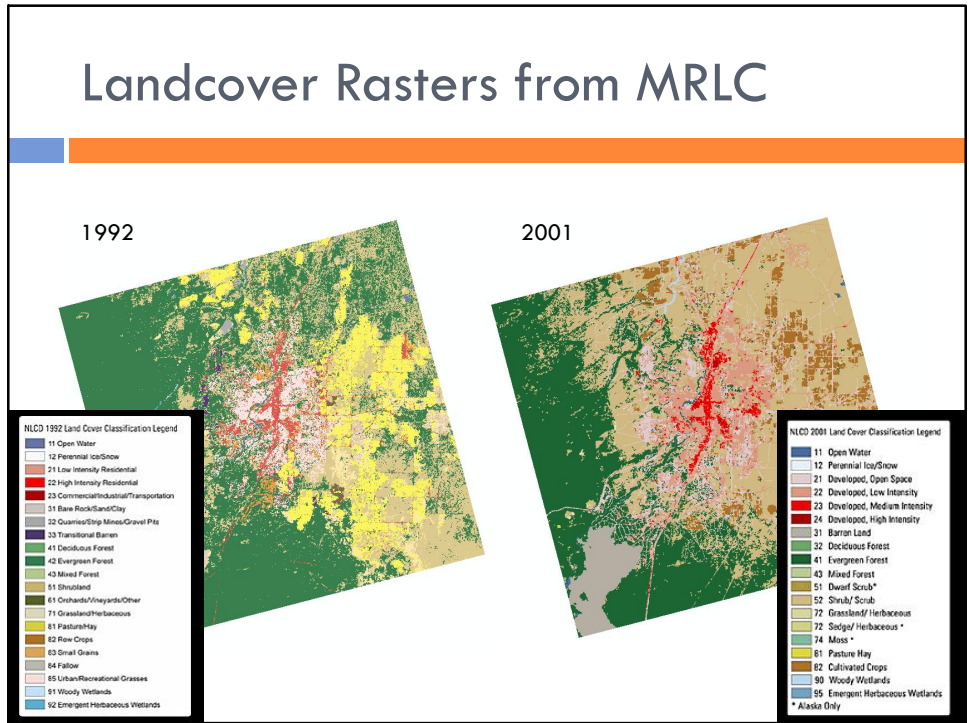
Raster Map of actual population of enumeration unit (N)



Reclassification of Landcover Rasters (R_A)



Landcover Rasters from MRLC



Checking on definitions

Barren

- 31 Bare Rock/Sand/Clay
- 32 Quarries/Strip Mines/Gravel Pits
- 33 Transitional

Forested Upland

- 41 Deciduous Forest
- 42 Evergreen Forest
- 43 Mixed Forest

Shrubland

- 51 Shrubland

Non-Natural Woody

- 61 Orchards/Vineyards/Other

Herbaceous Upland, Natural/Semi-natural Vegetation

- 71 Grasslands/Herbaceous

Herbaceous Planted/Cultivated

- 81 Pasture/Hay
- 82 Row Crops
- 83 Small Grains
- 84 Fallow
- 85 Urban/Recreational Grasses

Wetlands

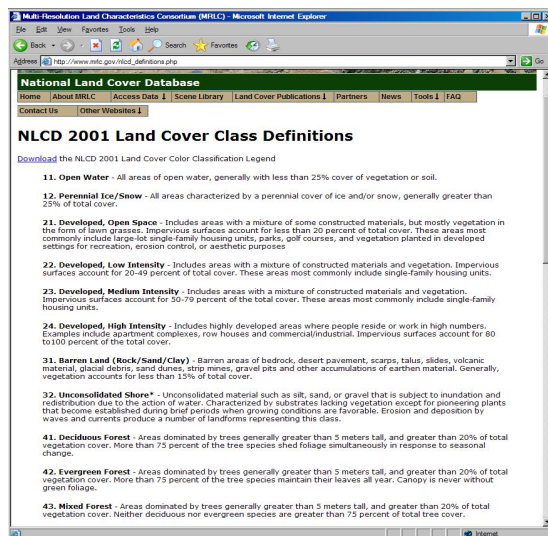
- 91 Woody Wetlands
- 92 Emergent Herbaceous Wetlands

Water - All areas of open water or permanent ice/snow cover.

11. *Open Water* - all areas of open water, generally with less than 25% cover of vegetation/land cover.
 12. *Perennial Ice/Snow* - all areas characterized by year-long surface cover of ice and/or snow.

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Checking on definitions



Initial Reclassification of Landcover Rasters

- Landcover codes first reclassified into 5 classes for clarity and uniformity:
- **1 = Residential** (includes MRLC codes 21 & 22)
- **2 = Commercial/Industrial** (codes 23 & 24)
- **3 = Agricultural** (codes 61, 71, 81, 82, 83, 85)
- **4 = Natural** (codes 41, 42, 43, 51, 51, 72)
- **5 = Water & Other Uninhabited** (codes 11, 12, 31, 32, 33, 90, 91, 92, 95)

Calculating Relative Density (R_A)

Population Density = Population/Area

Total Density = \sum Densities of all classes

Relative Density (R_A) = Population Density/Total Density

R_A Value for Classification = $R_A * 100$

1990					
	Residential	Comm./Ind.	Agricultural	Natural	
Population	848	546	846	321	
Area	454463	1035770	4699570	4237830	Total Den.
Density	0.001865938	0.000527144	0.000180016	7.57E-05	0.002649
Rel. Density	0.704434671	0.199008999	0.067960355	0.028596	
R_A Value	70.44346705	19.90089994	6.796035545	2.859597	100

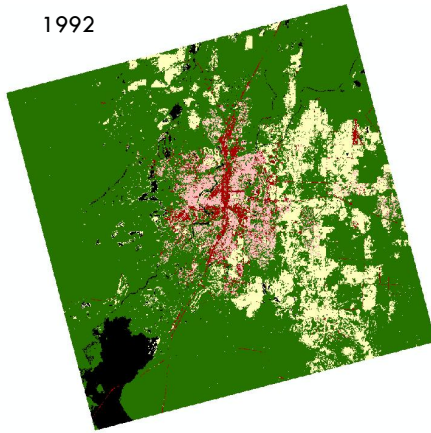
2000					
	Residential	Comm./Ind.	Agricultural	Natural	
Population	670	352	954	1452	
Area	426448	1051290	18072400	30552800	Total Den.
Density	0.001571118	0.000334827	5.27877E-05	4.75243E-05	0.002006
Rel. Density	0.783109128	0.166891299	0.02631153	0.023688042	
R_A Value	78.31091283	16.68912993	2.631153043	2.368804202	100

Relative Density Values (R_A)

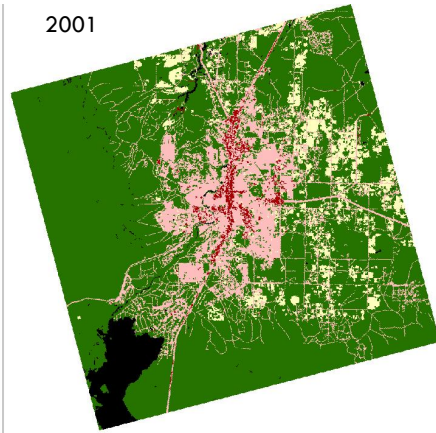
- 1990
 - 1 = Residential = 70
 - 2 = Commercial/Industrial = 20
 - 3 = Agricultural = 7
 - 4 = Natural = 3
 - 5 = Water & Other Uninhabited = 0
- 2000
 - 1 = Residential = 78
 - 2 = Commercial/Industrial = 17
 - 3 = Agricultural = 3
 - 4 = Natural = 2
 - 5 = Water & Other Uninhabited = 0

Relative Density Output Rasters (R_A)

1992

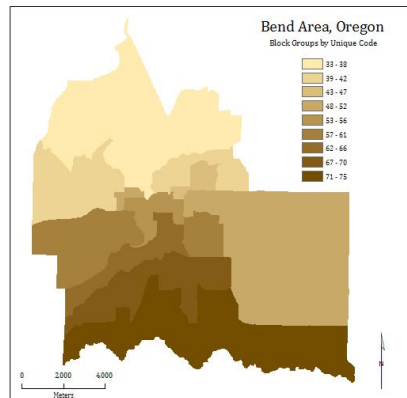


2001

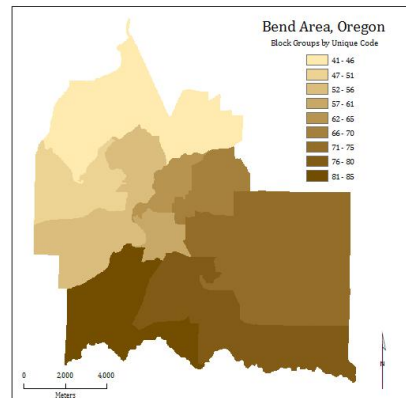


Block Group Raster by Unique Code

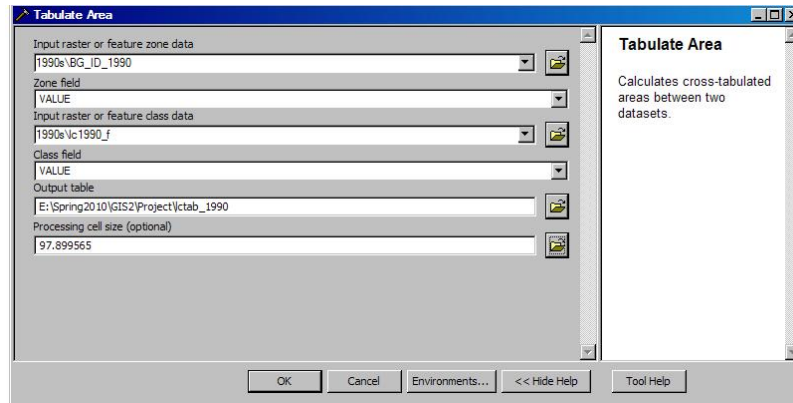
1990



2000



Tabulating Area with Zonal Toolset



Adding Proportional Data (Using Field Calculator)

- VALUE_1, VALUE_2, etc. = #of cells in each class (VALUE_5 not counted)
- TOTAL = VALUE_1 + VALUE_2 + VALUE_3 + VALUE_4 + VALUE_5
- P1 = VALUE_1/TOTAL, etc. (proportion of VALUE_1 to total number of cells)
- E = P_1*70 + P_2*20 + P_3*7 + P_4*3 (example is 1990; proportions established by relative density calculation)

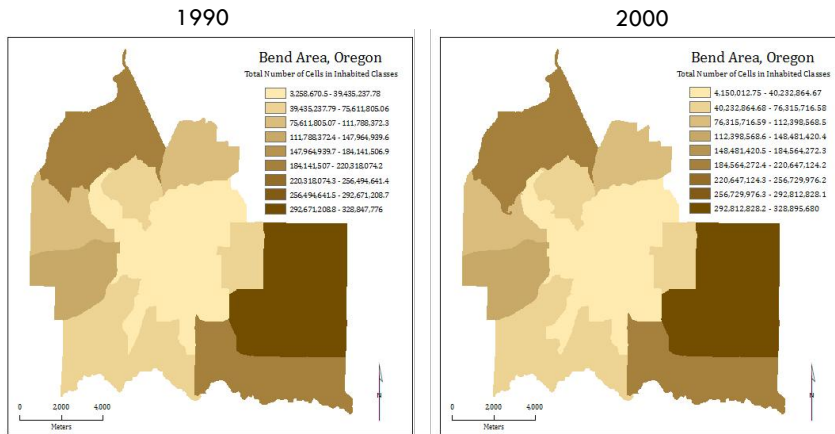
ID	VALUE_1	VALUE_2	VALUE_3	VALUE_4	VALUE_5	TOTAL	P1	P2	P3	P4	P5	E
1	44078813015	24118181435	18221913361	30111183201	53002091621	179221813361	0.24562	0.13322	0.10261	0.17001	0.18185	0.64619
2	90107770171	12438892381	12705292904	63473384054	17199413541	97640718811	0.09247	0.12744	0.13009	0.64841	0.24447	0.24447
3	10134842024	8592411888	87160447820	26243622117	17405446848	6001814485	0.24262	0.06661	0.13436	0.04848	0.14419	0.04848
4	10134842119	28919918475	27901622094	91112494922	26291572124	20144883088	0.28430	0.07780	0.21960	0.03030	0.33184	0.33184
5	90107770207	20031812162	48276614702	61948316122	10194812012	60144240215	0.17842	0.10261	0.10000	0.10000	0.10000	0.10000
6	90107770154	13892974003	38327208115	337348232315	28792474321	14442324418	0.08812	0.06661	0.03030	0.03030	0.03030	0.03030
7	48202071198	87178118182	18384184811	2871841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
8	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
9	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
10	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
11	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
12	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
13	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
14	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
15	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
16	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
17	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
18	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
19	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
20	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
21	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
22	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
23	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
24	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
25	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
26	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
27	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
28	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
29	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
30	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
31	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
32	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
33	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
34	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
35	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
36	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
37	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
38	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
39	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848
40	48202071198	13892974003	18384184811	18841841811	18841841811	18841841811	0.27111	0.04848	0.10000	0.04848	0.04848	0.04848

Joining Proportional Data to Population Data

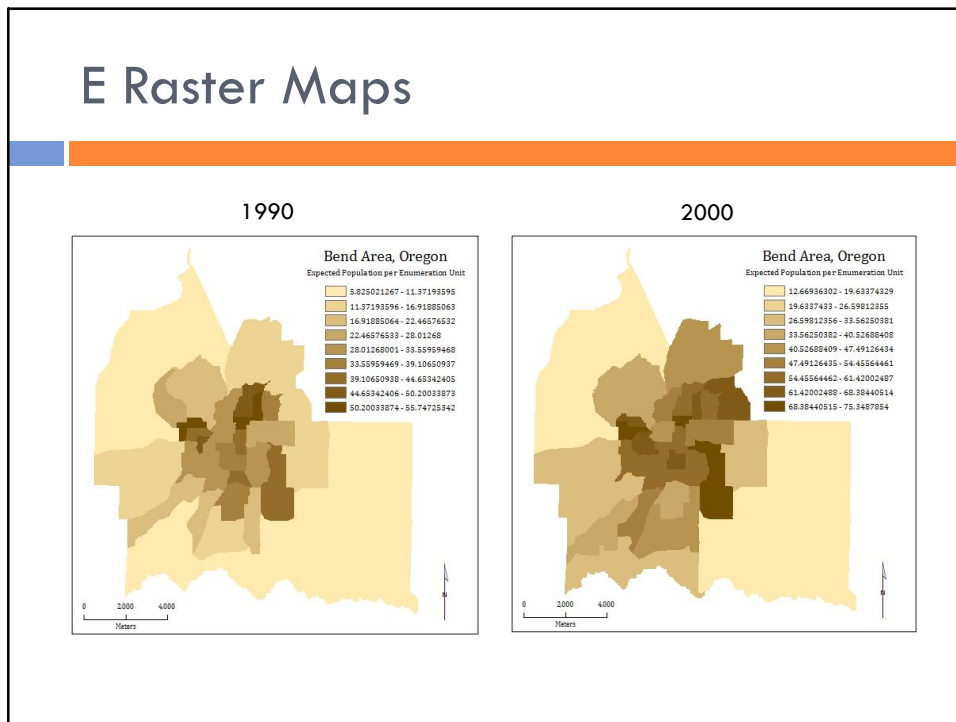
Simple table join (made not so simple by a simple problem)

BLOCKID	TOTPOP	VALUE_1	VALUE_2	VALUE_3	VALUE_4	VALUE_5	TOTAL	P1	P2	P3	P4	E	
33	13	33	8195269.38678	4441126.69726	24114161.1435	15827559.396	10811116.3095	194993097.625	0.141626	0.122097	0.123687	0.811696	6.864689
35	17	35	9613377.75316	1263089.2381	1232025.8964	6346798.8584	1716594.1584	37843371.8871	0.098247	0.127465	0.126065	0.846643	12.246547
37	835	37	15133648.8258	8038124.61066	6574646.79828	35241562.2177	1140334.64868	62968182.4465	0.240282	0.095861	0.104382	0.558495	21.144705
38	1111	38	7322424.13102	2261909.8478	4761.623894	18111249.9532	162933.52124	25743496.3559	0.294439	0.097863	0.001882	0.626358	23.558451
39	750	39	7697875.49828	292316.32362	4427958.64782	8193836.5362	8303778.2326	86271442.4033	0.379542	0.323395	0.048993	0.85107	8.911
40	1200	40	4782162.38941	4849688.33589	10001534.0257	11740797.8541	236688.119471	32184162.6073	0.148868	0.158855	0.335616	0.3648	18.692286
41	1087	41	9675853.70184	1589727.99203	38337.269115	3373662.32215	28752.874337	14472326.416	0.668212	0.086026	0.002649	0.233113	48.413246
42	624	42	4052622.35578	6727862.11662	153389.196461	3877484.76321	36267.731932	14881646.658	0.270777	0.455641	0.912566	0.206504	28.980777
43	792	43	4725072.11596	316282.717701	19168.649558	1044891.40089	38337.269115	6105214.88411	0.77394	0.051805	0.00314	0.171115	55.747253
44	1254	44	5348953.22639	2012708.20205	548308.912393	3788508.28764	28752.874337	11862876.2302	0.473777	0.172131	0.048721	0.32377	36.757377
46	840	46	3699649.36463	218951.16134	0	948846.153104	0	469562.66287	0.781341	0.86339	0	0.192606	54.74735
47	816	47	3468525.56994	335451.387259	19168.649558	737993.00797	0	4582138.158472	0.760504	0.073529	0.004202	0.161785	55.220588
48	1221	48	7484844.97304	5194704.03102	4049304.01331	1083887.3248	36287.315832	28389691.2453	0.284189	0.183188	0.179808	0.320596	24.489488
49	12	49	8398995.93204	4769860.4664	10573996.0445	22484825.9311	230022.794892	66071335.6265	0.125782	0.071221	0.462721	0.340286	14.49787
50	1088	50	13783060.3824	5415143.50004	134142009.684	17523733.999	143784.871882	328847987.486	0.041852	0.016467	0.407916	0.533785	7.715718
51	633	51	5201164.47613	308688.362622	854.324779	726488.683191	0	4248855.87702	0.15398	0.072238	0.002257	0.171588	54.751693
52	548	52	2769869.89108	722650.80324	124598.221125	826879.805646	76874.588231	1195978.47	0.25685	0.653846	0.911275	0.094128	38.857688
53	807	53	2913634.73276	785914.631884	690071.384078	1130958.3239	737993.00797	5526571.0728	0.527778	0.142381	0.125	0.204881	41.28125
54	858	54	3716222.86286	1848883.89188	102522.15133	883812.461088	47821.622884	1048353.33722	0.53528	0.213688	0.14538	0.888888	43.421198
55	847	55	2031876.85311	979889.21078	330623.798652	458800.95712	0	3258670.4248	0.823629	0.155882	0.079588	0.15	47.768824
56	684	56	3536816.84339	4571722.9185	236688.119471	2387328.22037	737993.00797	10716275.1027	0.330584	0.428855	0.022361	0.22093	32.466172
57	742	57	11800485.9738	8396338.23252	8688846.23468	87443739.282	3624254.19884	14888488.773	0.142482	0.081742	0.052893	0.781931	11.801038
58	1238	58	8204182.91868	5868022.43988	1706009.81905	5923112.71352	335451.387259	21689328.9745	0.378258	0.289996	0.079887	0.272889	33.247901
59	746	59	5861450.01243	3657882.86905	872173.554873	6191473.80712	1044891.40089	16532960.2435	0.36058	0.212174	0.052754	0.374483	39.978812
60	216	60	1845688.33237	2188473.91524	431284.810547	526428.3548	153348.196461	1245854.3788	0.873004	0.118732	0.022634	0.285189	43.481483
61	578	61	3096736.90358	403500.73189	106427.872987	948846.153104	0	8185013.38112	0.37922	0.492974	0.913881	0.19525	38.72834
62	771	62	2913634.73276	3297007.72392	220439.889913	1189703.28624	0	7180785.22483	0.383338	0.434343	0.02904	0.152778	38.217172
63	844	63	4274682.85138	2086938.39884	239688.119471	438039.42382	47821.622884	11501189.7348	0.371887	0.289897	0.020632	0.308833	31.833333
64	680	64	315248.8523	142584.30055	40254.840711	1376588.44337	9584.324779	838407.28288	0.498229	0.224756	0.083348	0.216588	48.321287
65	0	65	9776011.2744	1533481.96461	1628335.2124	28721997.4834	1584738.99288	38659935.8348	0.248488	0.038888	0.041083	0.873785	20.33878
66	13	66	18427745.5894	4283777.50991	384314.23831	4584832.84695	9584.324778	2308489.7428	0.452015	0.188124	0.169597	0.192584	37.15488
67	866	67	475335.2993	889185.26355	2071378.88288	10724885.4275	134180.546984	2443258.409	0.30278	0.114881	0.224887	0.457482	18.43878
68	2219	68	1522688.1417	1773100.08488	1877258.83829	8012488.1511	0	2888848.5772	0.578284	0.085888	0.062145	0.288875	42.88848
69	0	69	386121.89551	388289.9717	128979.57169	1285138.7081	38428.341595	2092162.517	0.114988	0.02088	0.058888	0.84388	17.80791
70	0	70	388165.15843	152888.61477	2223563.34889	4002448.2764	83983.823232	47802015.7747	0.081407	0.025653	0.048833	0.838397	9.184372
71	1132	71	432250.47525	8114789.20889	1259382.7584	17548888.67	584643.811588	40580031.1136	0.188519	0.188888	0.310345	0.424821	13.839773
72	571	72	2397917.54515	176215.7593	36281215.5378	89951895.8825	283810.18087	19183869.648	0.012281	0.09188	0.458837	0.18888	5.82821
74	521	74	1522688.6147	785914.631884	3431188.27082	38858978.8843	1064275.72687	44388389.4912	0.024897	0.071714	0.077339	0.88895	5.982882
75	846	75	2971140.89144	2741116.88674	17846012.7382	26931952.8285	230022.794892	50490222.8348	0.058848	0.05429	0.353455	0.53409	9.278223

TOTAL Raster Maps



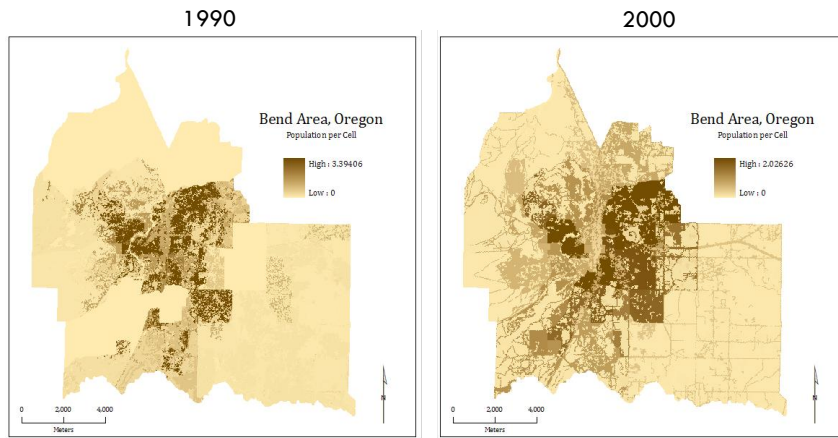
E Raster Maps



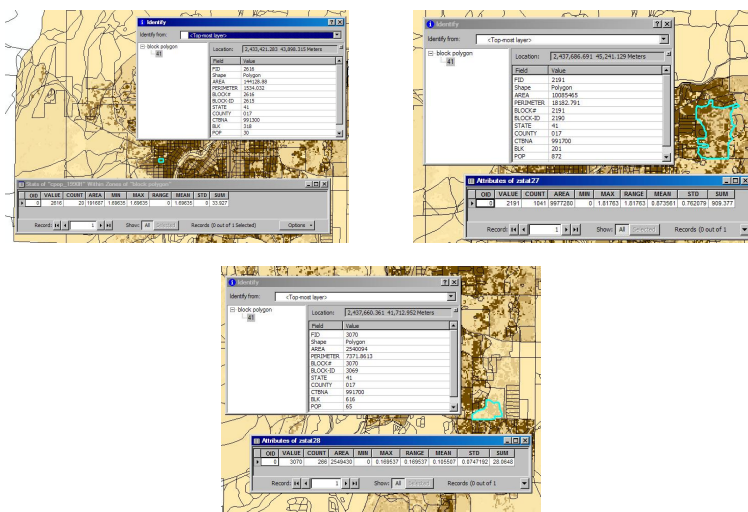
Calculating Population per Cell

- Using Raster Calculator in Spatial Analyst
- $([\text{Density Raster 1990}] * [\text{Population Raster 1990}] * \text{CellSize} * \text{CellSize}) / ([\text{E Raster 1990}] * [\text{TOTAL Raster 1990}])$
- $([\text{Density Raster 2000}] * [\text{Population Raster 2000}] * \text{CellSize} * \text{CellSize}) / ([\text{E Raster 2000}] * [\text{TOTAL Raster 2000}])$
- Cell Size = 97.8995648

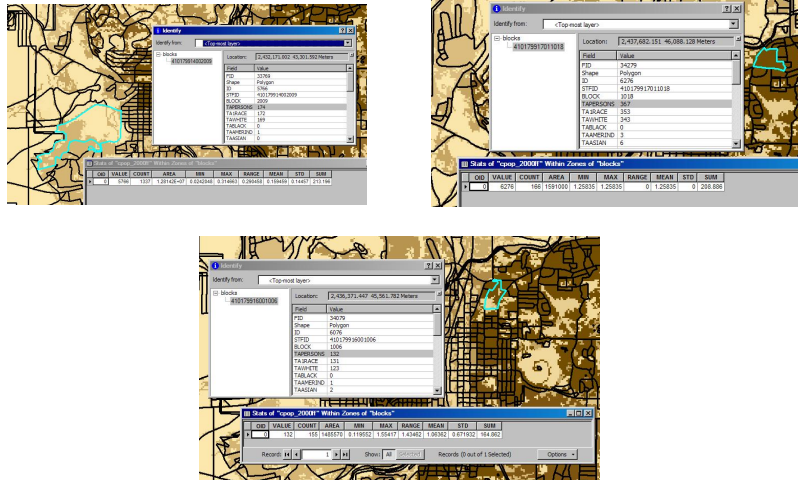
Final Dasymetric Maps



Checking Results, 1990



Checking Results, 2000



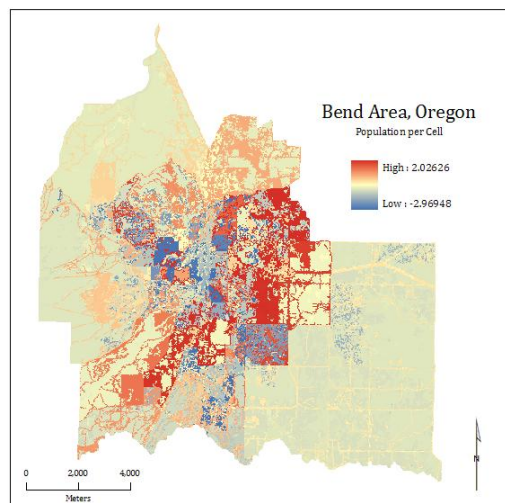
Difference in Population Density

2000 Population
Density Raster

Minus

1990 Population
Density Raster

Equals:



Conclusions

- Population Changes
 - Density appears to have increased the most in the Northeast and Southwest portions of Bend, though there are increases elsewhere.
 - Neither raster matched terribly well with census block population data, but 1990 was *slightly* better.
- Questions
 - Counterintuitive: Why was density higher in 1990 populated areas?
 - Could reclassification have been done differently to get a better outcome?
 - Why is 1990 more accurate than 2000 when checked?
 - Drop in Relative Density in agricultural and natural areas: is this relative to the increase in density in the city, or has population density dropped there as well?
 - What role does growth vs. expansion of UGB play?

Conclusions

- Shortcomings of Dasymetric Mapping
 - Not to be used for definitive data
 - Only a very general idea of the *possible* distribution and density of population
 - Different densities during different time periods
- Problematic Landcover Rasters
 - Not intended for comparisons
 - Issues with reclassification
 - Disparities in population change raster
 - With comparable rasters, results would give an even better idea of population density and distribution

Conclusions

- Possibility of a better study
 - ▣ Rasters with identical classification systems
 - ▣ Rasters with consistent land cover classification and from same time of year
 - ▣ Using census blocks instead of block groups
 - ▣ User gaining experience

Sources

- Websites
 - ▣ City of Bend Website: <http://www.ci.bend.or.us/>
 - ▣ GEOG 492/592 Course Website: <http://web.pdx.edu/~jduh/courses/geog492s10/index.htm>
 - ▣ Multi-resolution Landuse Characteristics Consortium Website: <http://www.mrlc.gov/>
 - ▣ Oregon Geospatial Data Library: <http://www.oregon.gov/DAS/EISPD/GEO/alphalist.shtml>
- People
 - ▣ Duh, Geoffrey: GEOG 592 Professor
 - ▣ Jones, Nadia: GEOG 592 Lab Instructor

Sources

- Course Materials
 - ▣ Course Lecture 4a (April 20, 2010)
 - ▣ GEOG 592 Lab 4 instructions
 - ▣ Holloway, S. R., Schumacher, J., and Redmond, R. L. 1997. "Dasymetric Mapping Using Arc/Info." *Cartographic Design Using ArcView and ARC/INFO*. High Mountain Press, NM