Modeling the Effect of Human Population on Land Use and Species Viability

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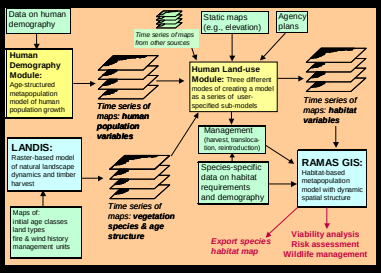
Conceptual Structure



Green: input data; Blue: existing modules;
Yellow: modules developed for this project

Human Population Projection

Age-structured metapopulation model

Uses linear algebra for projection

Parameters that need to be estimated for projection:

- Survival
- Fecundity
- Migration
- Initial abundance

Use algorithms to convert raw data into parameters

Survival

Survival = ${}_nS_x$ = Proportion of x-year-olds surviving to the next time step (x+n).

Standard life table data

National, regional, state, or local may be available

Larger populations are more reliable but less specific

${}_nS_x = {}_nL_{x+n} / {}_nL_x$

(note, 1st and last age classes receive special treatment)

Life Table

Age in years	Proportion dying			Of 100,000 born alive		Stationary population		Average remaining lifetime
	Correction							
	Uncorrected	Term	Corrected					
Period of life between two exact ages stated	Average Annual Death Rate	Fraction of Last Age Interval Lived	Proportion persons alive at beginning of year of age dying during year	Number living at beginning of year of age	Number dying during year of age	In year of age	In this year of age and all subsequent years	Average number of years of life remaining at beginning of year of age
-1			-2	-3	-4	-5	-6	-7
xto x+1			qx	lx	dx	Lx	Tx	ex
0-1	-	0.20189	0.00692	100,000	692	99,448	7,949,122	79.49
1-5	0.00043	0.38034	0.00173	99,308	172	396,806	7,849,674	79.04
5-10	0.00015	0.44086	0.00075	99,136	75	495,471	7,452,869	75.18
10-15	0.00021	0.55927	0.00106	99,061	105	495,075	6,957,397	70.23
15-20	0.00043	0.51829	0.00215	98,956	212	494,269	6,462,322	65.3
20-25	0.0005	0.49486	0.00251	98,744	248	493,093	5,968,053	60.44
25-30	0.00056	0.53093	0.00281	98,496	277	491,831	5,474,960	55.59
30-35	0.00075	0.53241	0.00374	98,219	367	490,237	4,983,129	50.73
35-40	0.00108	0.52856	0.00539	97,852	527	488,016	4,492,892	45.92
40-45	0.00155	0.53557	0.00772	97,324	752	484,876	4,004,876	41.15
45-50	0.00262	0.53352	0.01303	96,573	1,258	479,929	3,520,000	36.45
50-55	0.00417	0.5252	0.02066	95,315	1,970	471,897	3,040,072	31.9
55-60	0.00623	0.52087	0.03068	93,345	2,864	460,008	2,568,175	27.51
60-65	0.01023	0.51915	0.0499	90,481	4,515	441,551	2,108,167	23.3
65-70	0.01528	0.52869	0.07374	85,966	6,339	414,892	1,666,616	19.39
70-75	0.02387	0.5242	0.11296	79,627	8,994	376,736	1,251,724	15.72
75-80	0.0379	0.51735	0.1736	70,632	12,262	323,571	874,988	12.39
80-85	0.06191	0.51851	0.26941	58,371	15,726	253,994	551,418	9.45
85+	0.14338	-	1	42,645	42,645	297,423	297,423	6.97

Abridged life table for white women, California, 1990.
Available from the California State Government:
http://www.dhs.ca.gov/hisp/chs/OHIR/Publication/OtherReports/LifeExpectancy.htm

Fertility

Raw data are age-specific birth rates per 1000

National, state, and local data available

Divide by 1000 and multiply by the time step (n) to get ASBR for matrix model

Also need to incorporate sex ratio

Birth Rates

YEAR	BIRTH RATE BY AGE OF MOTHER							
	Under 15 [1]	15-19	20-24	25-29	30-34	35-39	40-44	45 AND OVER [2]
2001	0.6	45.1	110.9	127.2	102.3	49.6	11.3	0.9
2000	**0.7**	**48.1**	**114.8**	**127.0**	**101.5**	**48.5**	**11.2**	**0.8**
1999	0.9	50.2	116.3	122.5	95.8	46.0	10.4	0.8
1998	0.9	53.6	119.8	122.3	93.1	45.0	10.4	0.7
1997	1.1	56.7	122.8	121.6	91.4	44.4	10.4	0.7
1996	1.3	61.6	128.1	123.6	92.6	44.0	10.5	0.6
1995	**1.5**	**67.2**	**128.2**	**123.9**	**91.9**	**43.7**	**10.3**	**0.7**
1994	1.6	70.2	130.0	125.3	91.9	43.5	10.1	0.7
1993	1.5	71.3	132.8	127.5	92.4	43.5	9.8	0.6
1992	1.5	71.7	134.8	128.8	93.8	44.5	9.7	0.6
1991	1.5	72.9	135.7	132.2	94.3	44.6	9.4	0.6
1990	**1.4**	**70.0**	**135.4**	**133.4**	**95.6**	**44.2**	**9.1**	**0.6**
1985	**1.0**	**49.3**	**113.1**	**120.0**	**81.4**	**32.8**	**6.2**	**0.4**
1980	**0.9**	**52.4**	**116.2**	**111.2**	**67.4**	**24.7**	**5.1**	**0.3**
1975	**1.5**	**50.7**	**109.2**	**104.1**	**55.4**	**20.4**	**4.8**	**0.3**
1970	**0.8**	**68.3**	**156.2**	**134.3**	**70.1**	**29.2**	**7.1**	**0.4**

Birth rates are live births per 1,000 female population in specified age group. Modified from Table 2-2, California Center for Health Statistics, Office of Health Information and Research, web page http://www.dhs.ca.gov/hisp/chs/OHIR/vssdata/2001EX.htm.

Migration

Most important to human population change.

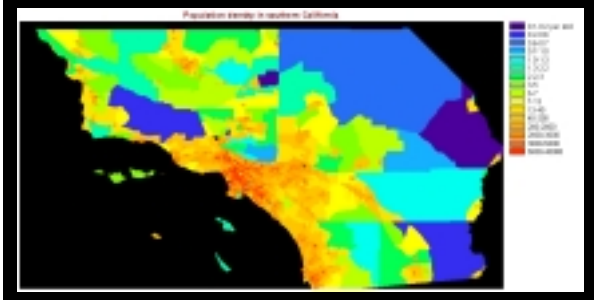
Model requires "gross" migration data.

Available data:

- total number of migrants from/to each county in US
- proportion moving by move type for each state
  Move types: within state, between states, and from abroad
- age-specific moving rates by move type
- total number of foreign immigrants by county

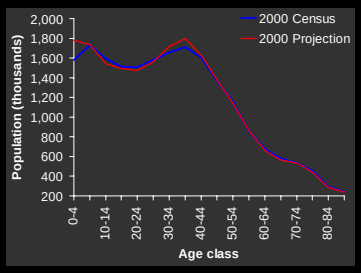
Algorithms use these data to construct an age specific dispersal rate matrix.

Projected Population Density



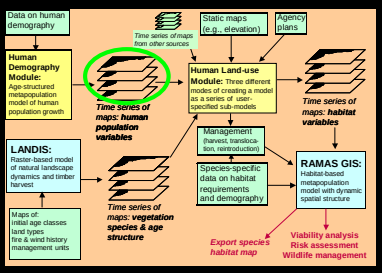
Population density in southern California, projected one five-year time step with methods developed in this project. Population shown by census tract.

Projection Accuracy



Comparison of the projection of ten southern California counties by age class to the results of the 2000 census (males and females are combined).

Conceptual Structure



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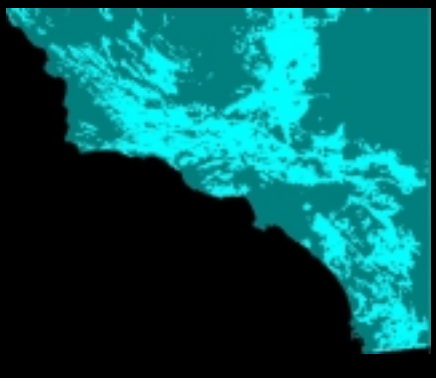
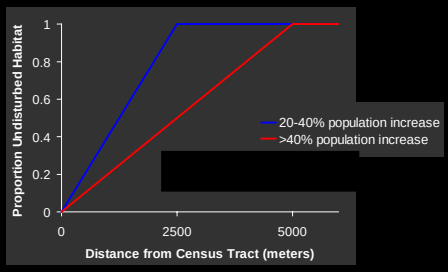
Change in Population Density

Percent change in human population density in southern California, projected for one five-year time step.

Sage Sparrow Habitat

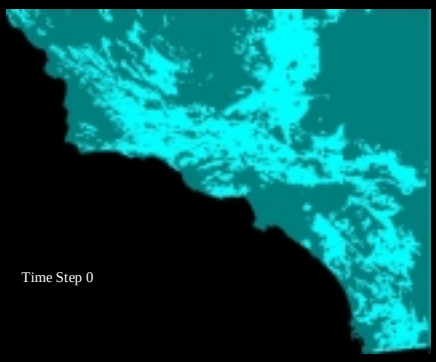


Population Density Impacts Habitat



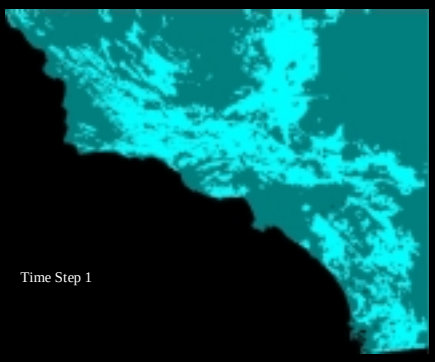
Hypothetical impact of change in human population density on habitat. At 5000 meters, large increases in population begin to degrade habitat. At 2500 meters moderate increases begin to exert an additional effect. This is a simple land use model.

Habitat Degradation



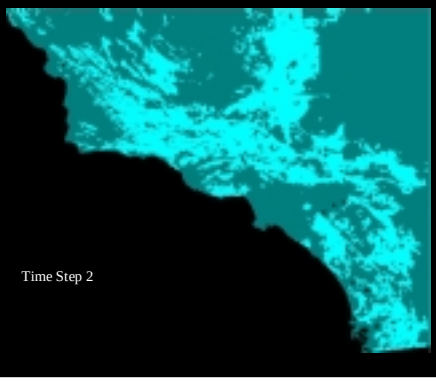
Time Step 0

Habitat Degradation



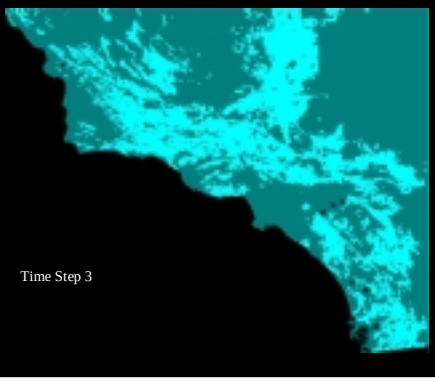
Time Step 1

Habitat Degradation



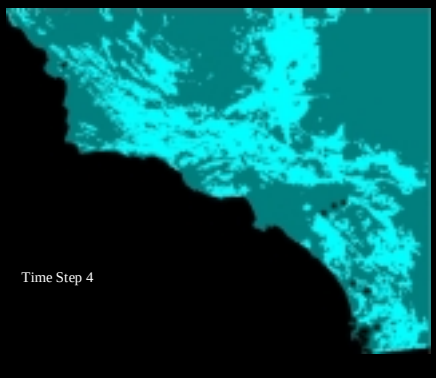
Time Step 2

Habitat Degradation

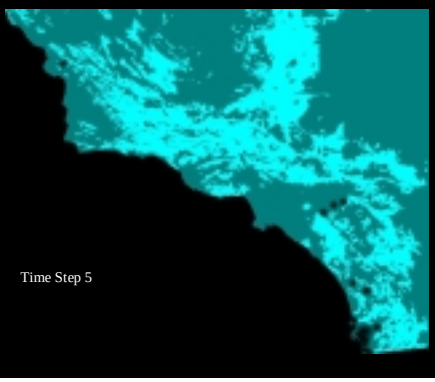


Time Step 3

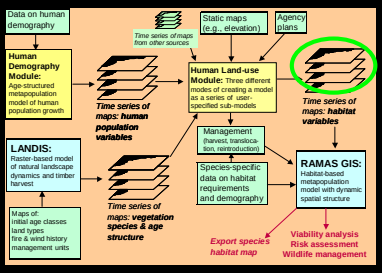
Habitat Degradation



Habitat Degradation



Conceptual Structure



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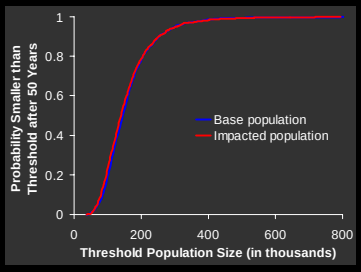
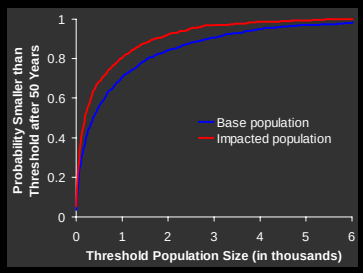
Sage Sparrow
Terminal Extinction Risk



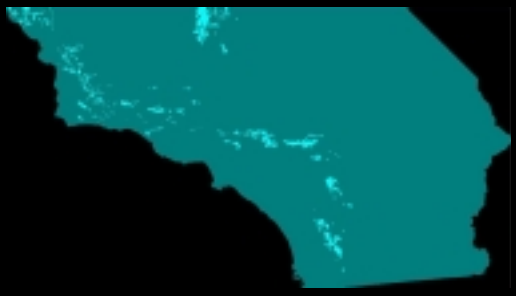
Gnatcatcher habitat

Habitat Degradation

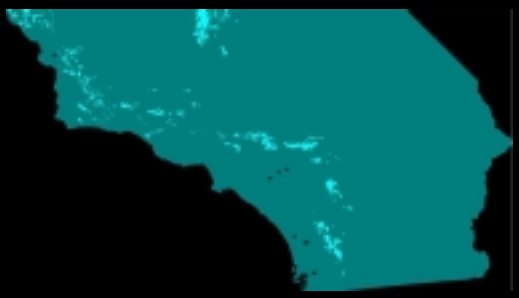
Gnatcatcher Terminal Extinction Risk



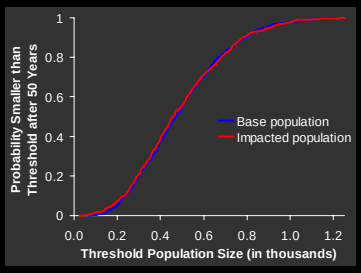
Spotted Owl Habitat



Habitat Degradation



California Spotted Owl Terminal Extinction Risk



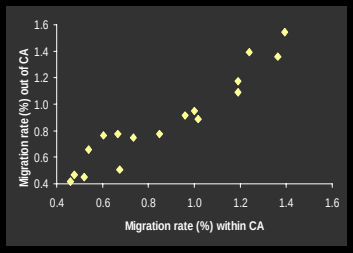
Viability Analysis Summary

- One effect was modeled.
  - Human population change impacts habitat.
  - No effect on vital rates.
    - e.g. roads, pets, pollutants, migration barriers, etc.
- Viability effect magnitude is species-specific.
  - Base population trajectory matters.
  - Density model differences matter.
    - Ceiling vs. contest.
  - Location matters.
- Change in human population density matters.
  - Even when overall population is not really growing.

Modeling Approach Summary

- Human population can be conveniently modeled.
  - Automation for standardized data.
  - User input where data is coarse or lacking.
- Time series maps of human socio-demographic variables provide input to land use model.
  - User is free to specify relationships.
- Time series maps of landscape change provide input to population viability models.
- The impact of alternate scenarios on population viability may then be explored.

Emigration Immigration Correlation



Correlation between migration rate of CA residents within CA (different residence 5 years ago in the same state) and out of CA, as a percentage of the population. Each point in the plot represents a different age class. The correlation coefficient is 0.96.