LAND USE ALLOCATION

MODULE STRUCTURE

The purpose of the land use allocation module is to calculate land use scenarios that are realistic, internally consistent, and can be easily updated. These future transportation/land use scenarios must also be realistically influenced by transportation measures including transit improvements and land use policy decisions.

Operational land use allocation models were first developed by Lowry in the 1960s.[1] In a Lowry-type model, basic employment is considered the fundamental engine of growth. It is specified by zone as a model input. Residential land use and population are allocated by zone to provide employees for basic industry. Service employment is allocated by zone to serve the new residences. The service employment requires further residential land use which, in turn, requires further service employment. In this manner a new equilibrium is approached either iteratively, or in one step through the use of optimization techniques. The allocation to zones is done with a gravity model. In general, land use is allocated to zones with shorter travel times, constrained by zonal control totals.

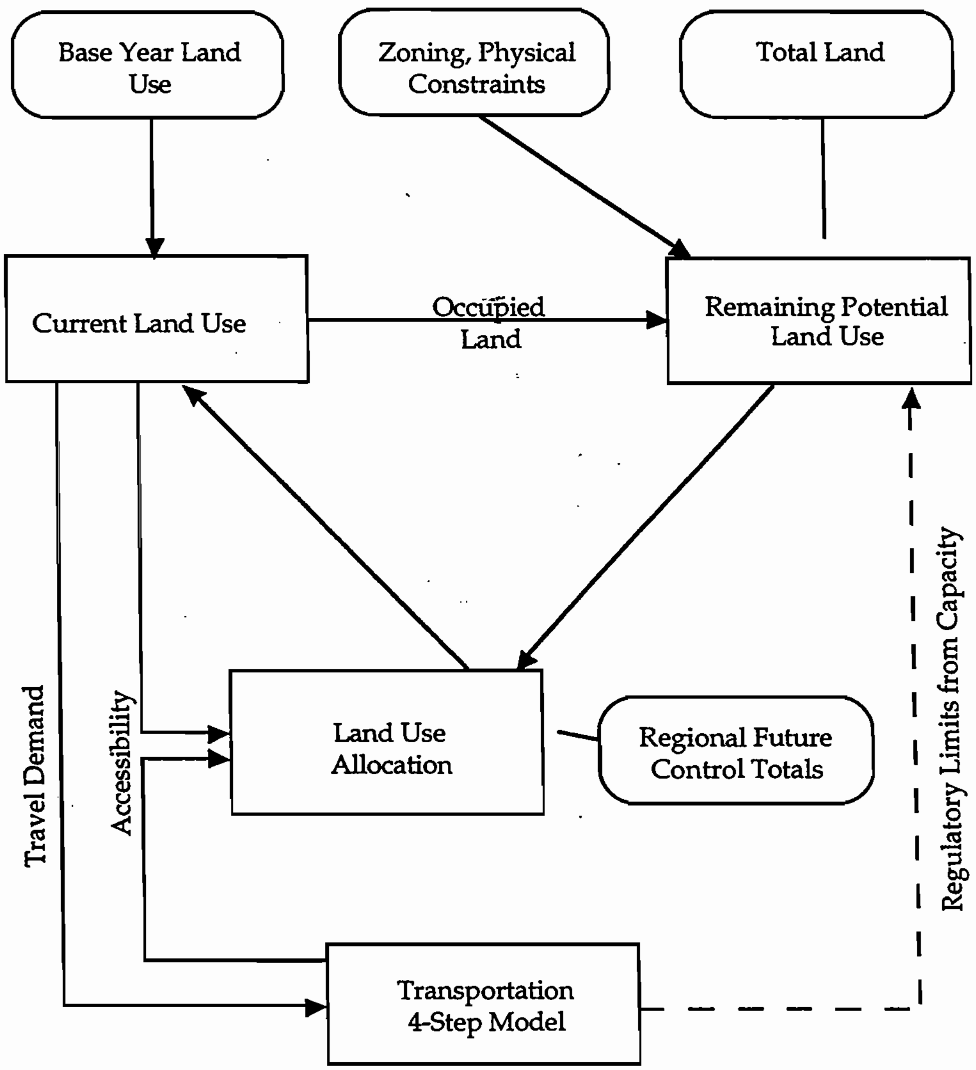
Putman linked land use models to transportation network models in the 1970s.[2] These Lowry/Putman models have been applied to many large urban areas in the United States. We have updated the Lowry/Putman model structure to better represent suburban growth areas in the 1990s. Instead of designating employment as "primary" and "secondary," it is categorized as retail or non-retail. Instead of housing location being determined by the workplace of the "primary worker," allocation is based on the generalized accessibility to all destinations. Generalized accessibility is calculated using a nested logit formulation[3], so that land use allocation incorporates transit accessibility. In a final enhancement, the effects of regulation on land use development are explicitly incorporated into the model structure.

---

[1]Lowry, I. S., 1964. *A Model of Metropolis*, RM-4035-RC. Santa Monica, CA: The Rand Corporation.
[2]Putman, S. H., 1983. *Integrated Urban Models*, London, Pion, Ltd.
[3]Ben-Akiva, M., and S. R. Lerman. 1985. *Discrete Choice Analysis: Theory and Application to Travel Demand*. Cambridge, MA and London: MIT Press: 276-322.

RESOURCE
SYSTEMS
GROUP

Figure 3: Land Use Allocation Module Overview



An overview of the land use allocation module is presented in Figure 3. The major module inputs are existing land use and available land. Available land is calculated based on total land area and physical and regulatory constraints. The accessibility of each zone for each land use type is calculated based on current land use and the accessibility calculated using outputs from the 4-step transportation model. Regional future control totals are developed by the user outside of the module. The user may also choose to feedback regulatory limits on growth in congested areas, although this feedback is not present within the module.

DATA SOURCES

The primary data inputs for the land use allocation module are:

- housing and employment by type by traffic analysis zone (TAZ) for base year 1993 and for 1980.
- data on physical constraints, and
- zoning data for the County.

Table 2 shows the key data files used in the land use allocation modeling process, as well as the compiled program used to manipulate the data for the model.

Table 2: Data Files and Program for Preparing Land Use Allocation Model

File/Program	Description
C93.LUX	File of Existing Base Year Land Use (Housing and Employment)
C93.ZON	Zoning File (an input to the CALU.EXE program)
C93.GIS	File Containing Physical Constraints Data from the GIS (an input to the CALU.EXE program)
CALU.EXE	Program to Calculate Allowed Land Use, by TAZ, in the County
C93.ALU	File of Allowed, or Potential, Land Use, by TAZ, in the County for the Base Year (output from the CALU.EXE program)

HOUSING AND EMPLOYMENT

Data development for housing and employment for the base year (1993) is described in detail in the Trip Generation Data Sources section. Housing data were acquired from electronic property databases from each municipality. Employment data were acquired from Dun & Bradstreet. In both cases, data records were address-matched in order to allocate housing units and employment to transportation analysis zones. Existing land use for the base year, 1993, are contained in the C93.LUX file.

Employment was further subdivided into 6 categories according to SIC codes which came with the Dun & Bradstreet employment database. This process is described in Appendix 6.

Comparing the base year land use with a past year land use enabled the estimation of the weighting parameters of the land use allocation module. Historical land use data were readily available only at the municipal level for 1980. The sources were the 1980 U.S. Census for housing data, and the Vermont Department of Employment and Training for employment data. In order to maintain data comparability, 1991 employment data and 1990 housing data from the same sources were used to estimate the weighting parameters.

Tables 3 and 4 provide the housing and employment data used in the estimation process, respectively.

Table 3: 1980 and 1991 Housing Data by Municipality Used in Estimating Weighting Parameters for the Land Use Allocation Model (Source: U.S. Bureau of the Census)

Municipality	1980 Housing	1991 Housing
Burlington	13,107	14,758
S Burlington	3,819	5,185
Shelburne	1,798	2,413
Williston	1,309	1,877
Essex	4,684	6,063
Winooski	2,330	2,828
Colchester	3,872	4,985
Charlotte	824	1,100
Milton	2,080	2,748
Westford	454	598
Underhill	673	977
Jericho	1,052	1,415
Bolton	260	367
Richmond	1,025	1,336
Huntington	383	572
Buels Gore	0	0
St. George	236	270
Hinesburg	895	1,363
Total	38,801	48,855

Table 4: 1980 and 1990 Employment Data by Municipality Used in Estimating Weighting Parameters for the Land Use Allocation Model (Source: Vermont Department of Employment and Training)

Municipality	1980 Employment	1990 Employment
Burlington	25,966	29,110
S Burlington	7,409	13,130
Shelburne	1,278	2,499
Williston	1,556	3,048
Essex	10,716	13,120
Winooski	2,314	5,101
Colchester	1,894	5,037
Charlotte	389	443
Milton	560	1,348
Westford	70	88
Underhill	153	279
Jericho	325	493
Bolton	20	40
Richmond	414	745
Huntington	24	99
Buels Gore	0	0
St. George	35	0
Hinesburg	633	817
Total	53,756	75,397

ZONING DATA

Key inputs to the land use allocation module are zoning and physical constraints data. Combined, these data indicate the potential developability for housing and employment within each TAZ in the County.

The zoning portion of these data were compiled by Beth Humstone, a Burlington planning consultant. To make the task of compiling 18 separate ordinances workable, the variety of zoning ordinances were analyzed and classified into 21 generic zoning categories. These categories include 5 strictly commercial zones, 6 strictly residential zones, 9 zones permitting some mix of residential and commercial, and 1 zone each of municipal and open space zoning.

In order to develop the 21 zoning categories, the following issues were taken into account:

- minimum lot size
- minimum road frontage
- minimum front yard setback
- minimum rear yard setback
- minimum side yard setback
- minimum open space required
- parking required and fractional setbacks available for parking
- area per parking space
- number of stories
- loading required and area per loading space

Table 5: Land Use Zoning Used in the Land Use Allocation Model

Land Use Zone #	Residential Permissions (Units per Acre)	Commercial Permissions (Square Feet per Acre)	GIS Zn_cat
1	0	6,000	1 (commercial)
2	0	12,000	2 (commercial)
3	0	20,000	3 (commercial)
4	0	30,000	4 (commercial)
5	35	65,000	5
6	> 10.9 20	0	A (resided)
7	10.8 – 3.49 10	0	B (resided)
8	3.5 – 1.08 3.5	0	C (resided)
9	1.09 – .36 .5	0	D (resided)
10	.37 – .09 .25	0	E (resided)
11	≤ 0.10 .1	0	F (resided)
12	0	0	M (resided)
13	0	0	O (resided)
14	12	60,000	A5 (mixed)
15	10	6,000	B1 (mixed)
16	10	12,000	B2 (mixed)
17	10	20,000	B3 (mixed)
18	3.5	6,000	C1 (mixed)
19	3.5	12,000	C2 (mixed)
20	3.5	20,000	C3 (mixed)
21	.25	20,000	E2 (mixed)

The permissions implied by these zoning categories are shown in Table 5.

After the zoning data were compiled, they were given to the GIS personnel at CCRPC for digitizing a zoning overlay into the system. For some municipalities the zoning overlay already existed; for others, a new zoning overlay had to be created. The zoning permissions shown in Table 5 are contained in the file C93.ZON.

PHYSICAL CONSTRAINTS DATA

The GIS at the Chittenden County Regional Planning Commission contains several data layers that are essential in the task of estimating potential land use at the TAZ level. The data layers employed in this analysis are:

- Municipal Boundaries
- Transportation Analysis Zones
- Zoning
- Soil Type (as indicated by septic suitability)
- Existing and Approved Sewer Service Areas
- Protected Land
- Surface Water

The soil type data were aggregated according to septic capability. Table 6 shows the septic capability categories used in the process of estimating potential land use.

Table 6: Septic Capability Indices for Chittenden County

Septic Capability Class	Description
1	Not Classified
2	Dump, Beaches, Water
3	Conventional/Soil Replacement
4	Conventional
5	Mound
6	Test, Mound, Curtain Drain
7	Marginally Suitable
8	Unsuitable
9	Existing Sewer Service
10	Approved Sewer Service

RESOURCE
SYSTEMS
GROUP

Through the data overlay process, the GIS facility estimated the total acreage within each subcategory of land for each Transportation Analysis Zone. This process yielded over 2,600 individual records for the entire 299 zone County. For example, TAZ #1 is broken out into 9 individual data records, as shown in Table 7.

Table 7: Example from Zoning/Constraints Database for TAZ #1

Zoning Category	Acres Within Zoning Category	Soil Type Indicator	Acres Within Soil Type Indicator
7	70.04	1	0.09
7	70.04	5	1.26
7	70.04	10	66.86
7	70.04	11	1.83
13	146.74	5	1.11
13	146.74	6	128.63
13	146.74	10	15.59
13	146.74	11	1.41
14	0.04	6	0.04

The physical constraints data and the zoning data are used by the CALU.EXE program, which calculates the total *potential* number of dwelling units and the total employment supportable within each TAZ in the County.

Within CALU.EXE are 3 sets of assumptions that affect the calculation of total potential land use. The first set of assumptions pertains to the effect of soil class on minimum lot size for residential zones and on maximum commercial square footage per acre for commercial zones:

1) For soil types 5 and 6 (mound systems required), residential lots are a minimum of 5 acres in size, despite the prevailing zoning class; commercial permissions cannot exceed 1,000 square feet per acre for these soil types.

2) For soil types 7 and 8 (marginally suitable and unsuitable for septic systems), residential lots are a minimum of 10 acres in size, despite the prevailing zoning class; commercial permissions cannot exceed 500 square feet per acre for these soil types.

The second set of assumptions within CALU.EXE pertains to the fraction of mixed use zones developable for residential versus employment land uses. Research conducted by Michael Munson, PhD. of RESV, Inc. revealed that the portion of mixed use zones developed for residential versus commercial land uses is dependent on 2 main factors:

RESOURCE
SYSTEMS
GROUP

1) Whether the mixed use zone was located within the Central Business District in Burlington (TAZs 17-65), South Burlington (TAZs 93-113), Essex Junction (TAZs 218-223), or Winooski (TAZs 260-263); and,

2) Whether the mixed use zone was served by sewer or not.

Table 8 shows the assumptions implicit in the CALU.EXE program pertaining to the fraction of land devoted to potential residential land uses within mixed use zones.

Table 8: Fraction of Land Devoted to Potential Residential Land Use Within Mixed Use Zones

	Sewered	Unsewered
CBD	10%	90%
Non CBD	80%	95%

Finally, since the land use allocation module is designed to allocate employees rather than square footage of commercial space, an assumption within CALU.EXE was made that made a conversion from units of area to units of employees. Inspection of actual employment and commercial square footage data for Burlington shows that 550 square feet per employee is a reasonable average, and this conversion factor is used within CALU.EXE.

PARAMETER ESTIMATION

The logit-based land use allocation module uses the same utility calculations used in the distribution module and the mode split module. The land use allocation module uses three aggregated land use categories:

1) Residential including single-family and multi-family housing,

2) Retail including retail and high commercial employment, and

3) Non-retail including industrial, institutional, and low commercial employment.

Two additional set of parameters were estimated for the land use allocation module functions based on the utility functions. These include a set of scaling parameters, α (alpha), and a set of weights, w. The generalized accessibility GA_n for land use type n is a function of the weight parameters w_{nm} and the paired accessibility functions A_{nm}, summed over all land use types m.

Equation 1: Generalized Accessibility Function

$$GA_n = w_{nRes} * A_{nRes} + w_{nRet} * A_{nRet} + w_{nNonret} * A_{nNonret}$$

An accessibility function A_{nm} is calculated for the accessibility of each land use category to every other land use category m. Therefore, there are a total of 9 accessibility functions. These accessibility functions are based on the logit equation corresponding to the predominant trip type for the land use type pair. For example, residential land use interacts with retail land use primarily through home-based nonwork trips. The values used for α are those estimated for the distribution model for that trip type. The predominate trip patterns assumed, along with associated values of α, are given in Table 9.

Table 9: Predominant Trip Types Assumed for Land Use Pairs

From \ To	Residential	Retail	Non-Retail
Residential	Home- Based Nonwork — α=5.5	Home- Based Nonwork — α=5.5	Home-Based Work — α=2.5
Retail	Home- Based Nonwork — α=5.5	Nonhome-Based — α=4.5	Nonhome-Based — α=4.5
Non-Retail	Home-Based Work — α=2.5	Nonhome-Based — α=4.5	Nonhome-Based — α=4.5

Equations for the accessibility from land use type n to land use type m for zone i (A_{nmi}) are given below. A_{nmi} is a function of the existing land use of type m in zone j, and the composite utility function CU_{nmij}, from land use type n to land use type m, from zone i to zone j.

Equation 2: Partial Accessibility Function

$$A_{nmi} = \sum_{mj} (LU_{mj} * CU_{nmij}).$$

The composite utility function CU_{nmij} is a function of α and the utility functions Vauto, Vpool, Vwb, and Vbus for auto, carpool, walk/bike, and bus modes, respectively. The utility functions are documented in Appendix 5.

Equation 3: Composite Utility Function for Nonhome-Based Trips

$$CU_{nmij} = e^{\left(\alpha \ln\left(e^{\theta_A \ln\left(e^{Vauto} + e^{Vpool}\right)} + e^{Vwb} + e^{Vbus}\right)\right)}$$

Estimation of land use allocation module parameters was based on the historical changes in activity patterns observed over the period 1980 - 1993. Because historical data were not available at the Transportation Analysis Zone (TAZ) level, 1980 estimates were developed using data on change at the municipal level, except for Burlington which was split in two. Weight parameters were estimated using multiple linear regression techniques, based on 1980 land use, 1993 land use, and estimated potential land use. These estimated weight parameters are summarized in Table 10.

Table 10: Estimated Weight Parameters, w, in Land Use Allocation Module

From \ To	Residential	Retail	Non-Retail
Residential	0.000012740	0.0	0.0
Retail	-0.000009801	0.000048374	0.0
Non-Retail	0.000018740	0.000054653	-0.000011488

A positive weight parameter indicates that greater accessibility causes greater allocation. A negative weight parameter indicates that greater accessibility causes less allocation. These affects are correlational; they are not necessarily causal. For example, in mixed use zones there is competition for land. If the area strongly attracts one type of land use, other uses may be crowded out. The zero weights represent cases where no strong effect is observed in the historical data.

FUTURE INPUTS TO THE LAND USE ALLOCATION MODEL

The land use allocation module is run in 5 year increments, beginning with the base year 1993 and proceeding to 1998, 2003, 2008, and 2013. Future scenario analyses are driven by forecasts of population, households, and employment.

Michael Munson, PhD., of RESV, Inc., was retained to research existing forecasts and to propose a set of forecasts for future scenarios. Since the land use allocation module allocates housing, the population projections had to be converted to households. This was done by using the average household size for the County of 2.72 taken from the 1990 Census. Table 11 shows the final population and housing forecasts used as a basis for future scenarios. Table 11 also shows the 5 year household increment, which is used as an input to the model.

Table 11: Population and Household Projections for Chittenden County, 1993-2013

Year	Population Projection	Annual Growth Rate Over 5 Year Period	Households	5 Year Increment of Households
1993	137,259		50,463	
1998	148,426	1.58%	54,568	4,105
2003	157,608	1.21%	57,944	3,376
2008	166,790	1.14%	61,320	3,376
2013	176,149	1.10%	64,761	3,441

As a basis of comparison, Chittenden County population growth rates were 1.75% from 1950-60; 2.91% from 1960-70; 1.54% from 1970-80; and 1.32% from 1980-90.

Several sources were consulted in the process of developing employment forecasts. The Bureau of Economic Analysis, within the Department of Commerce, and Woods & Poole, a private econometrics firm, each have developed employment projections for Chittenden County. Both sets of projections converge on annual growth rates for the period of the simulation. The employment projection emerging from these growth rates is shown in Table 12.

Table 12: Employment Projections for Chittenden County, 1993-2013

Year	Employment	Annual Growth Rate Over 5 Year Period	5 Year Increment of Employment	RET	NON RET
1993	80,105				
1998	85,491	1.31%	5,386	1077	4309
2003	90,217	1.08%	4,726	945	3781
2008	94,061	0.84%	3,844	769	3075
2013	96,916	0.60%	2,856	571	2285

The land use allocation module receives as input increments of employment broken out into retail and non-retail categories. The Dun & Bradstreet database showed a consistent breakdown of these two aggregate employment categories across Chittenden County municipalities of 20% retail to 80% non-retail. This ratio is applied to the employment projections shown in Table 12 to arrive at the increment for each.