



# Real Estate Development Model

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# Outline

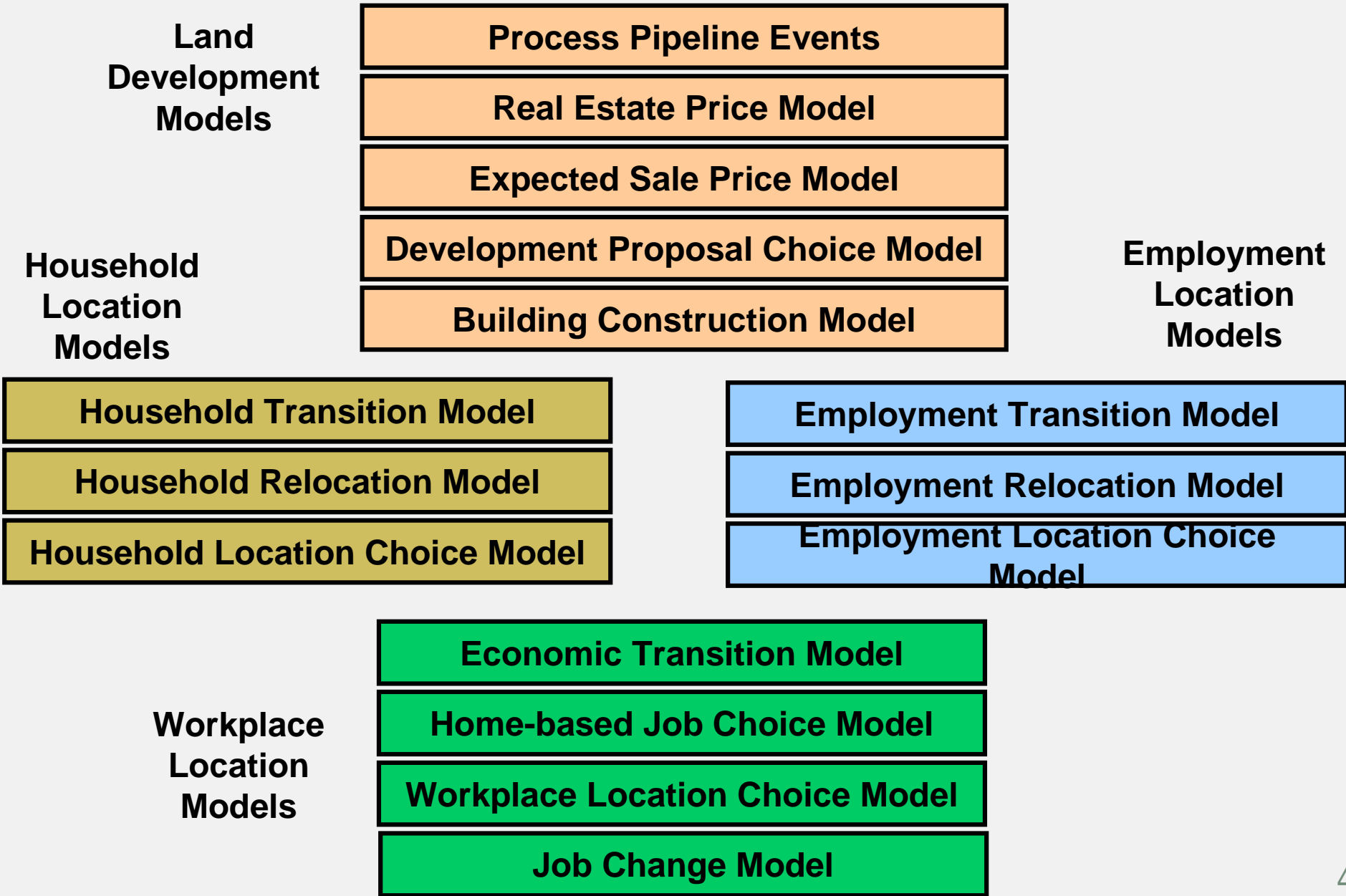
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- Overview of Real Estate Development (Developer) Models
- Development Project Location Choice Model
- Project Proposal Sampling Model

# UrbanSim Models



# UrbanSim Models



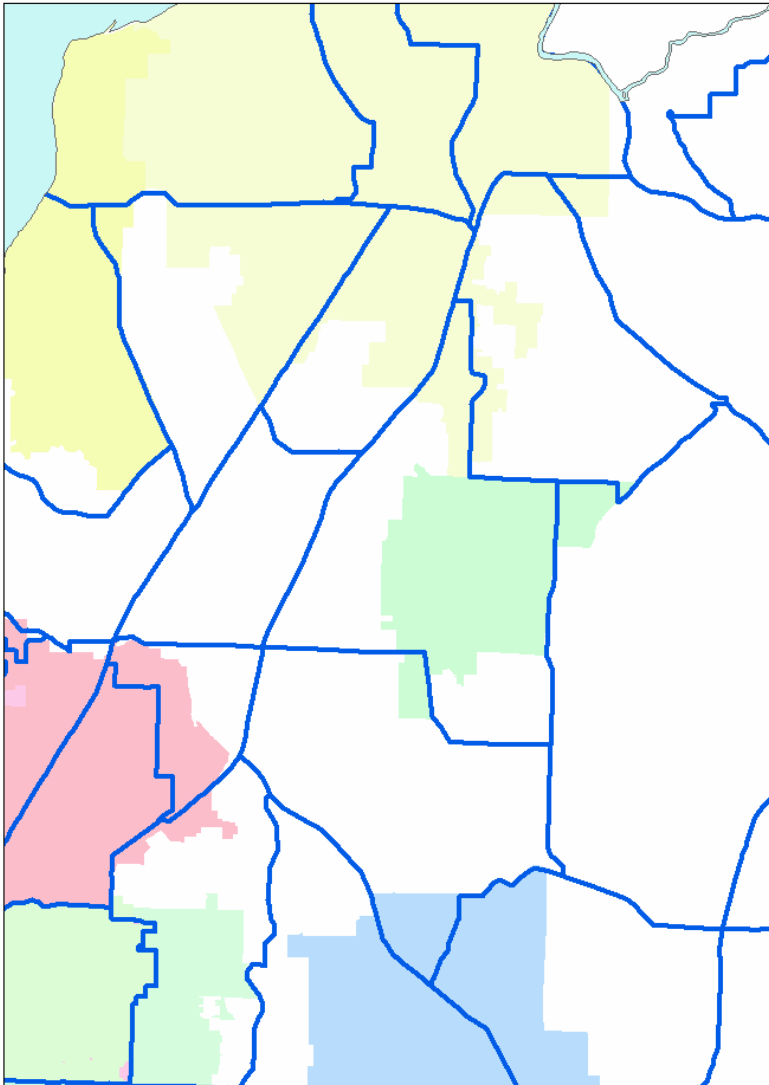
# Real Estate Development Model

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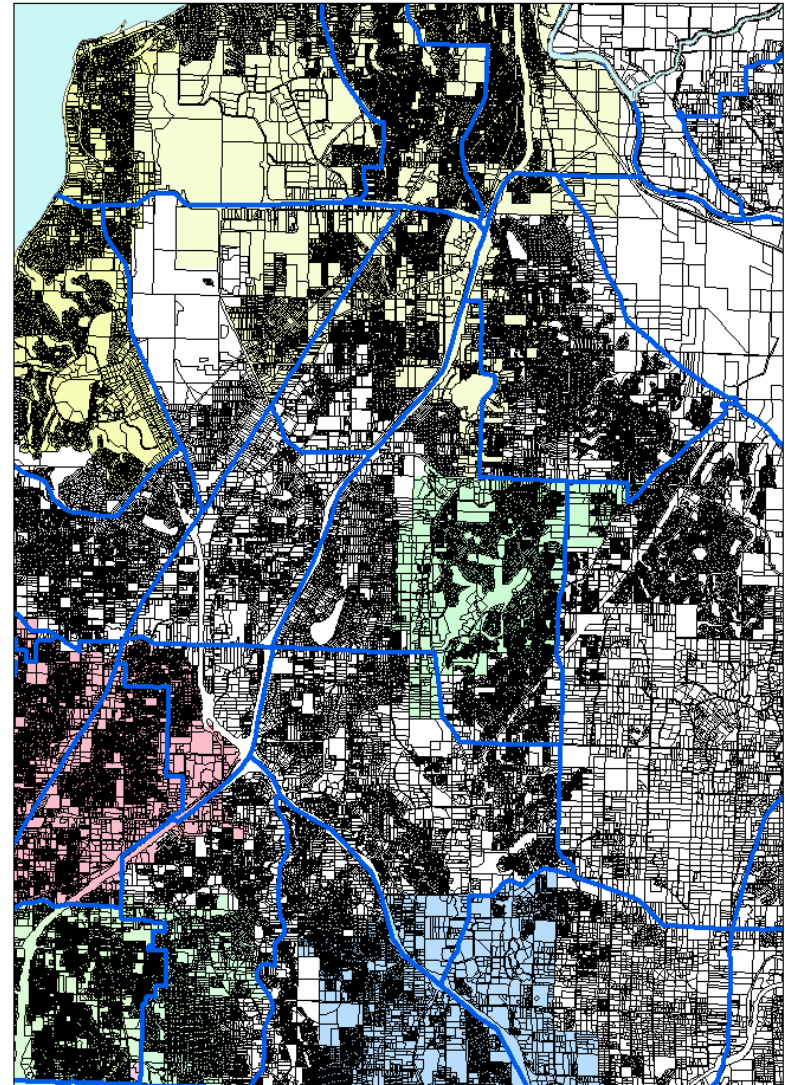
- Difficulties in studying Real Estate Supply (Dipasquale, 1999):
  - Ambiguity in accounting:
  - Diverse agents and complicated decision making process:  
Land owners, builders, investors
  - Poor data availability

# Choice of Geography

DRAM / EMPAL: Forecast Zones

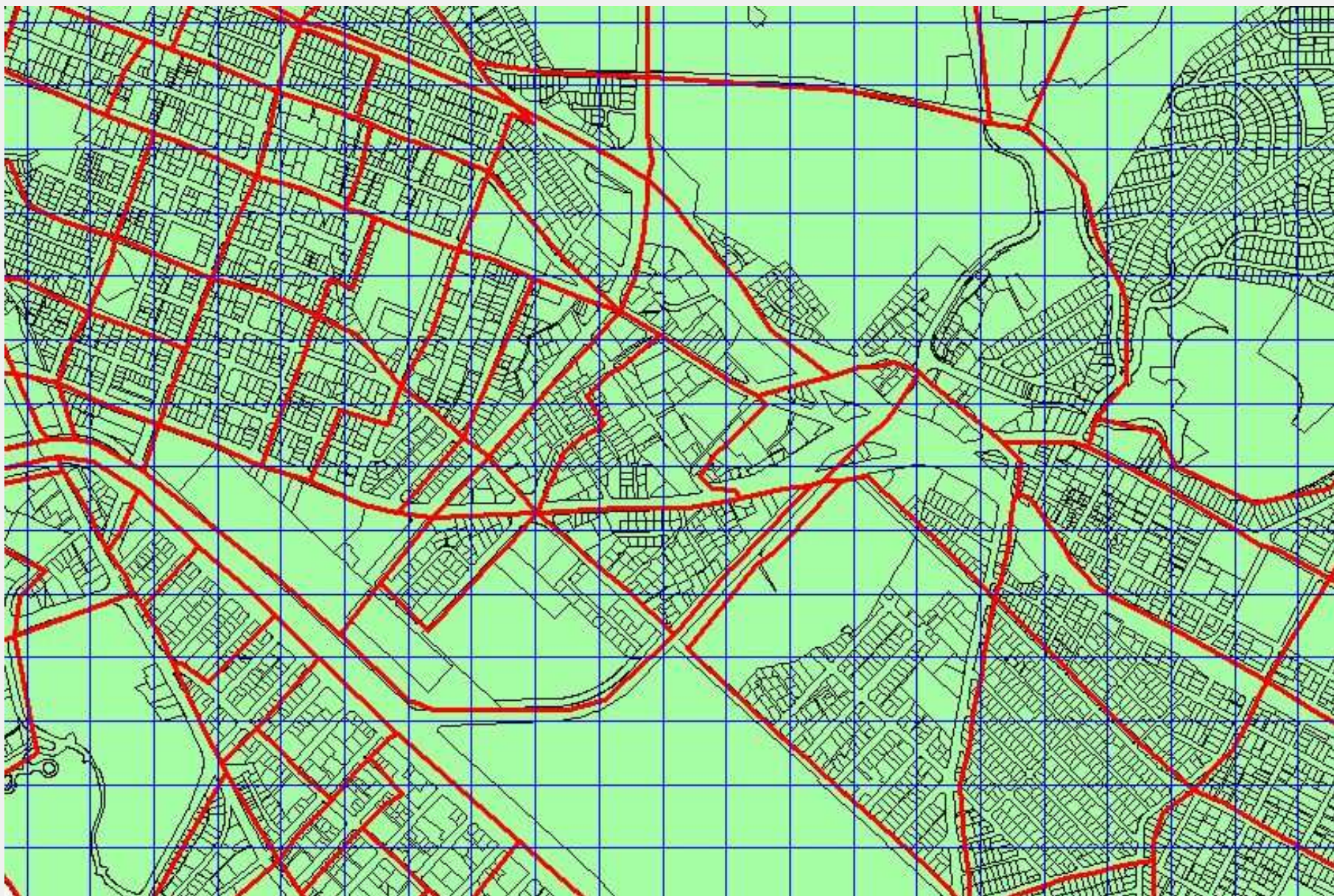


Individual Parcels



# Choice of Geography

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# Models of Real Estate Development

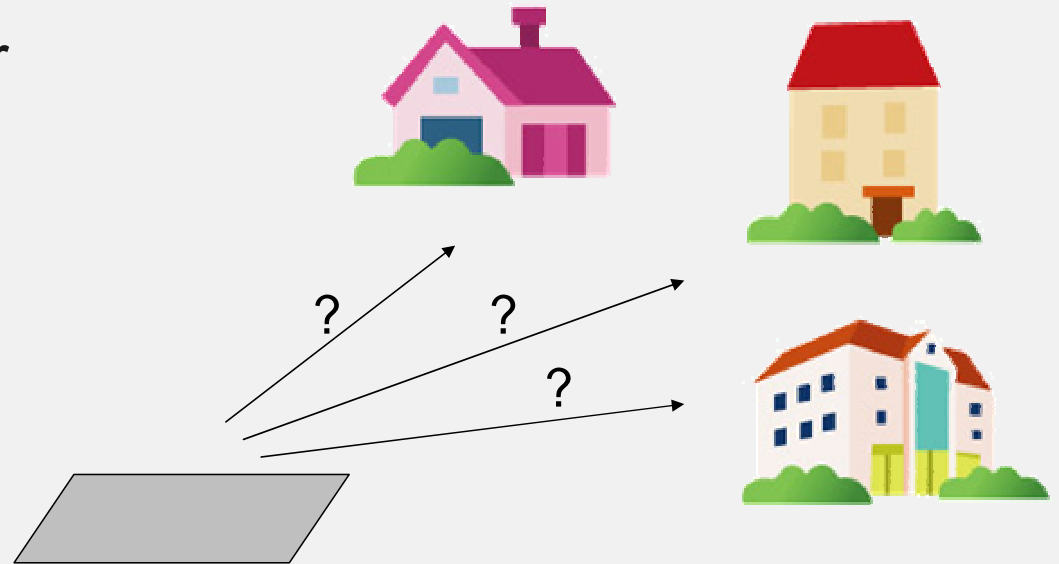
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- Allocation Model
  - allocating development in proportion to weights
- Transition Model
  - Site looking for a use; highest and best use
- Project Location Choice Model
  - Use looking for a site; Site selection problem
- Project Proposal Sampling Model
  - proposals competing on profitability

# State Transition Model

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- State transition model
  - Perspective of a land owner
  - Land/site looking for use
  - Emphasizes local and neighboring attributes



- Applications: CUF (Landis and Zhang, 1998); ILUTE (Miller et al., 2004); UrbanSim (Waddell et al., 2000, 2002); Land cover change models, e.g. SLEUTH

# State Transition Model

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- Decision makers: Land / Land Owners
- States/alternatives: Land use types, Development types
- Model Framework:
  - Discrete Choice Model
  - Cellular Automata - Markov chain
- Constraints: filtering choices included in alternative set

# Real Estate Transition Model

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- **Waddell and Gudmundur, 2003. Dynamic Simulation of Real Estate Development and Land Prices within an Integrated Land Use and Transportation Model System**
  - Decision makers: developable gridcells
  - Alternatives: no build + 24 development types
  - Model stratified by current development type: vacant land
  - Land use regulation on a gridcell limits its alternatives
  - Quantity of development determined by development templates - distributions of development quantity by transition pair

# Limitation of Transition Model

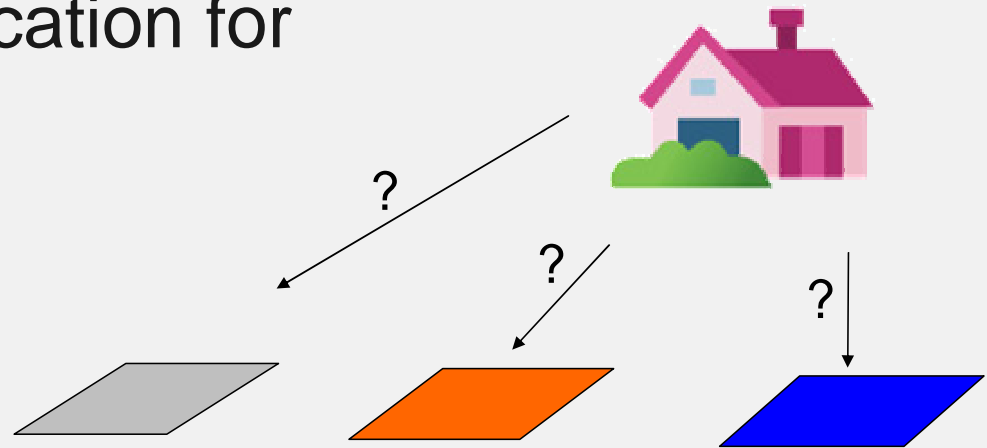
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- Bottom-up approach; emphasizes local context, but de-emphasizes larger context
- Requires alternative-specific constants for each transition type, which make the model rigid, and insensitive to changes in policy or conditions
- Fails to reflect competition among sites for a given project (the developers problem)

# Project Location Choice Model

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- Modeling location choice of real estate projects
  - Perspective of a property developer
  - Project searching for a site
  - Emphasizes optimal location for individual project



- Applications: ILUTE; UrbanSim; Haider and Miller, 2004

# Project Location Choice Model

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- Decision makers: Development Projects
- Size attributes: residential units or/and building sqft
- Alternatives: location with varying degrees of aggregation
  - Zones
  - Neighbourhoods
  - Gridcells
  - Parcels
- Constraints: limiting locations to be included in alternative set

# Building Location Choice Model (BLCM) of San Francisco Project

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- Decision makers: "buildings"
  - Constructed from development\_event\_history for estimation
  - Sampling new buildings from development\_event\_history in simulation
- Size attributes: residential units or/and building sqft
- Alternatives: parcels (sampling of alternatives)
- Filter: size attribute of a building  $<$  remaining capacity of parcels
- Model stratified by building type

# Building Location Choice Model (BLCM)

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Submodel: 6 (hotel)

Convergence achieved.

Akaike's Information Criterion (AIC): 97.967980998

Bayesian Information Criterion (BIC): 105.450518805

Number of Iterations: 12

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Log-likelihood is: -43.983990499  
Null Log-likelihood is: -112.239513595  
Likelihood ratio index: 0.608123831882  
Adj. likelihood ratio index: 0.563576240398  
Number of observations: 33  
Suggested |t-value| > 1.86989506697  
Convergence statistic is: 0.000964771270526

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Coeff_names	estimate	std err	t-values
ln_hholds_per_acre_in_zone	-0.335668	0.098788	-3.39787
ln_land_area	-2.7479	0.368748	-7.45199
ln_price	0.255571	0.118766	2.15188
lrt_travel_time_weighted_access_by_population	0.00351013	0.00159295	2.20354
lrt_travel_time_weighted_access_to_employment	-0.00086614	0.000432838	-2.00107

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# Limitation of Project Location Choice Model

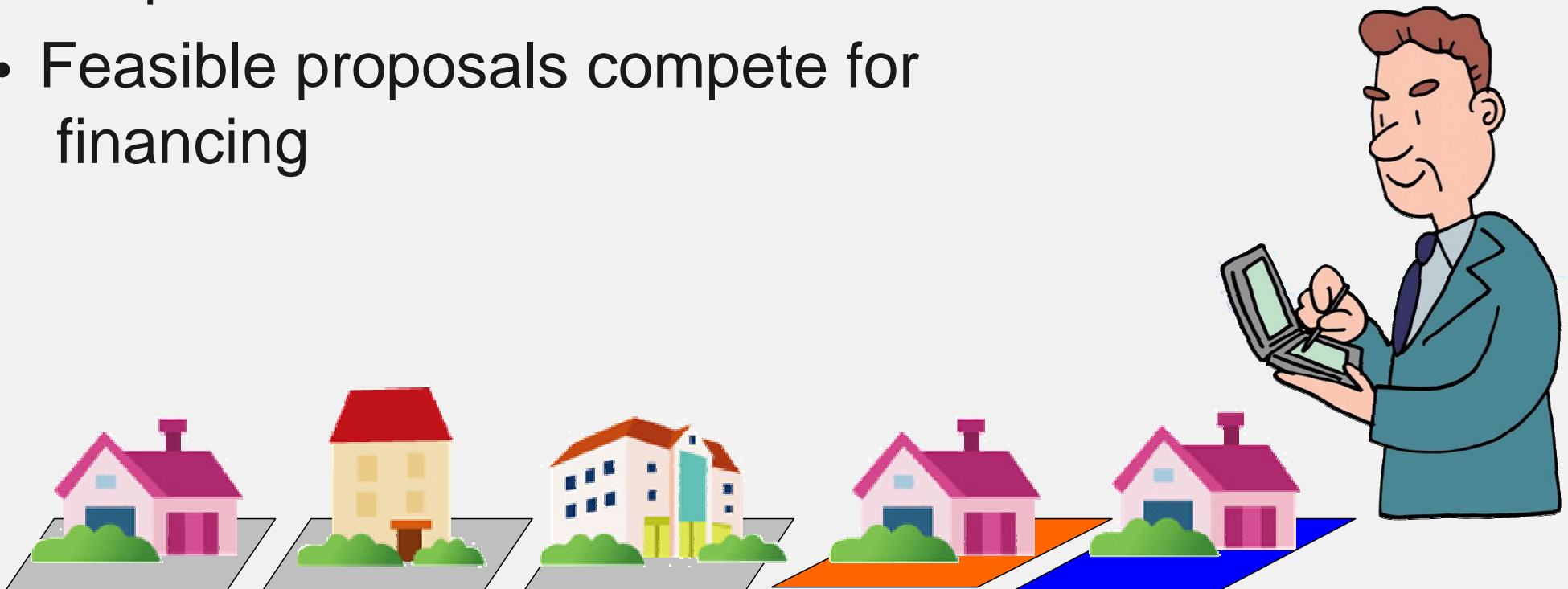
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- More difficult to capture spatial clustering of developments
- Composition of development project has to be determined exogenously
- Does not represent competition within a site across project types (the landowners problem); weak in respecting capacity constraints (dePalma, Picard, and Waddell, 2007)
- Possible violation of I.I.D assumption, common in location choice model

# Project Proposal Sampling Model

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- From the perspective of financial agents, reconciling the perspectives of landowners and developers
- A proposal combines a site with a development template
- Feasible proposals compete for financing



# Development Constraints



## Zoning

- Medium Density SF Residential
- Min Units 4.5, Max Units 8.7
- 2.5 acres / 107,000 SQFT size

## Other possible factors:

- Urban Growth Boundary
- Physical and environmental constraints: slope, wetland, flood plain

# Development Templates

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- Conceptual: standard housing type (Hooper and Nicol, 1999);
- Quantitative classification (Song and Knaap, 2007):
  - Cluster analysis on recent historical development
  - Identification factors: lot size, density (units per acre / far), floor space
- Hypothetical: ULI Reality Check, Criterion Paint the Town



# Development Templates



Table 2: Residential templates

ID	Template Type	Characteristics	Property type	Lot size range (min)	Lot size range (max)	Units per acre	Sample size
1	Subdivision	10- to 20-acre lots	SFH	37.00	150.00	0.08	14
3	Subdivision	3.3- to 10-acre lots	SFH	20.00	58.00	0.20	64
5	Subdivision	1.3- to 3.3-acre lots	SFH	12.00	35.00	0.46	86
7	Subdivision	0.67- to 1.3-acre lots	SFH	6.50	23.00	1.12	261
9	Subdivision	0.40- to 0.67-acre lots	SFH	4.00	14.00	2.05	325
11	Subdivision	0.25- to 0.40-acre lots	SFH	3.00	12.00	3.13	436
13	Subdivision	0.20- to 0.25-acre lots	SFH	2.50	10.00	4.45	715
15	Subdivision	0.15- to 0.20-acre lots	SFH	2.00	8.00	5.96	964
17	Subdivision	0.10- to 0.15-acre lots	SFH	2.00	6.50	8.41	585
19	Subdivision	0.050- to -0.10-acre lots	SFH	1.00	3.50	13.42	185
21	Single property	0.050- to 0.12-acre lots	SFH	0.05	0.12	10.61	11115
23	Single property	0.12- to 0.20-acre lots	SFH	0.12	0.20	6.20	21359
25	Single property	0.20- to 0.28-acre lots	SFH	0.20	0.28	4.37	16329
27	Single property	0.28- to 0.40-acre lots	SFH	0.28	0.40	3.07	11216
29	Single property	0.40- to 0.60-acre lots	SFH	0.40	0.60	2.09	8194
31	Single property	0.60- to 0.90-acre lots	SFH	0.60	0.90	1.37	5466
33	Single property	0.90- to 1.3-acre lots	SFH	0.90	1.30	0.92	8009
35	Single property	1.3- to 1.8-acre lots	SFH	1.30	1.80	0.64	3407
37	Single property	1.8- to 2.8-acre lots	SFH	1.80	2.80	0.42	6316
39	Single property	2.8- to 4.0-acre lots	SFH	2.80	4.00	0.30	1917
41	Single property	4.0- to 5.8-acre lots	SFH	4.00	5.80	0.20	7653
43	Single property	5.8- to 8.0-acre lots	SFH	5.80	8.00	0.15	1310
45	Single property	8.0- to 12-acre lots	SFH	8.00	12.00	0.10	1231
47	Single property	12- to 18-acre lots	SFH	12.00	18.00	0.07	294
49	Single property	18- to 50-acre lots	SFH	18.00	50.00	0.04	439
51	Single property	townhouse extra large lots	Condo	0.67	61.18	2.38	35
53	Single property	townhouse large lots	Condo	0.38	23.89	4.35	143
55	Single property	townhouse medium lots	Condo	0.26	21.98	6.60	151
57	Single property	townhouse small lots	Condo	0.19	26.64	9.34	173
59	Single property	low-rise large units	Condo	0.14	20.61	12.79	181
61	Single property	low-rise medium units	Condo	0.11	13.64	17.06	161
63	Single property	low-rise small units	Condo	0.09	11.01	22.02	110
65	Single property	med-rise large units	Condo	0.07	3.58	27.95	103
67	Single property	med-rise medium units	Condo	0.06	4.55	37.68	104
69	Single property	med-rise small units	Condo	0.06	1.22	54.51	108
71	Single property	high-rise large units	Condo	0.11	2.72	102.20	43
73	Single property	high-rise small units	Condo	0.25	0.72	206.30	8

# Choose Among Project Proposals

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- Probabilistic Profit Maximization:

- $$U_i = \text{profitability} + \varepsilon_i$$

- $\varepsilon_i$  = random error term
- If assumed to Independently Identically Gumbel Distributed, proposals are sampled with weight of  $\exp(\text{profitability})$

# Profitability

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- Return on Investment (ROI)  
= ( revenue – total cost ) / total cost
- Revenue = Net Present Value (expected sale price):
  - Assume proposals are built on their site
  - Apply Hedonic regression model to predict property values of proposed projects

# Expected Sale Price

- Coefficients for Hedonic regression (SFH)

Variable	Coefficient	t-statistics
Intercept	2.192	84.501
Whether property is close to water	0.224	189.915
Age of property	-0.0020	-79.046
Is property built before 1940	0.092	59.059
<u>ln</u> building <u>sqft</u>	0.822	884.283
<u>ln</u> lot <u>sqft</u>	0.145	301.501
Is of premium building quality	0.0648	73.997
<u>ln</u> average income in TAZ	0.298	170.826
<u>ln</u> employment density in TAZ	0.027	44.209
<u>ln</u> population density in TAZ	0.0384	52.506
Trip weighted average travel time	-0.005	-27.0403
<u>ln</u> generalized cost traveling to CBD	-0.159	-63.715
School district specific fixed effect (56 in total, not showing due to limit of space)		significant
Number of Observation: 785088		
Adjusted R-squared: 0.765		

# Expected Sale Price

- Coefficients for Hedonic regression (MFA)

Variable	Coefficient	t-statistics
Intercept	-1.06466	-10.154
Whether property is close to water	0.114781	13.4462
Age of property	0.00293166	26.1313
<u>ln</u> building <u>sqft</u>	1.62904	1078.05
<u>ln</u> number of units in building	-0.0724484	-23.5851
Is of premium building quality		
<u>ln</u> average income in TAZ	0.136954	14.7372
<u>ln</u> generalized cost traveling to CBD	-0.0632105	-5.72444
Large area specific fixed effect (18 in total, not showing due to limit of space)	-	-
Number of Observation: 27135		
Adjusted R-squared: 0.491		

# Expected Sale Price

- Coefficients for Hedonic regression (Condo)

Variable	Coefficient	t-statistics
Intercept	0.304637	1.367
Whether property is close to water	0.263	15.742
Age of property	-0.0018	-5.061
<u>ln</u> building sqft	1.510	186.327
<u>ln</u> number of units in building	0.0310501	8.00414
<u>ln</u> average income in TAZ	0.0936	5.902
<u>ln</u> population density in TAZ	0.0563	8.883
<u>ln</u> employment accessible within 30 minutes transit and walk	0.0304223	6.2217
<u>ln</u> generalized cost traveling to CBD	-0.0940894	-6.19377
Is zone in core suburban cities	-0.146351	-9.68671
Is zone in smaller suburban cities	-0.18573	-11.0005
Is zone in rural areas	0.140946	3.70511

Number of Observation: 5463  
Adjusted R-squared: 0.879

# Costs

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- Acquisition cost: land cost (new development); land cost + cost for existing structure (redevelopment)
- Demolition cost (redevelopment)
- Construction cost
- Financial costs: interests
- Other costs/subsidies: impact fees, development incentives

# Developer Model Step 1: Select Parcel for Evaluation

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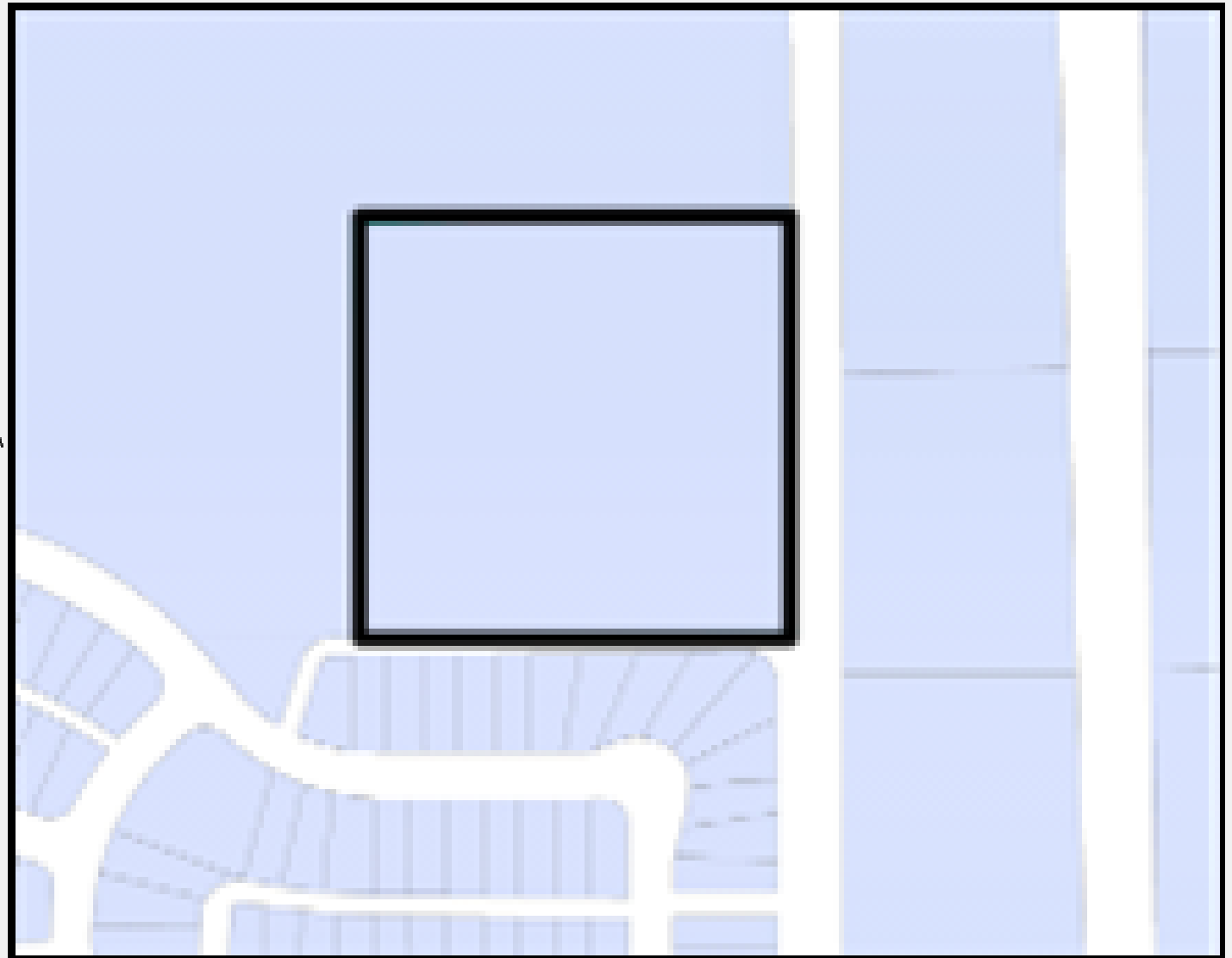
## BEFORE DEVELOPMENT

### parcel

```
parcel_id = 9551
zone_id = 35
ownership_type_id = 5
land_use_type_id = 26
city_id = 3
county_id = 4
plan_type_id = 6
mpa_id = 1
census_block_id = 532
raz_id = 23
parcel_sqft = 43560
unit_price = 1.76
assessor parcel id = 13708011 A
tax_exempt_flag = 0
is_in_floodplain = 0
is_on_steep_slope = 0
is_in_fault_zone = 0
is_in_archaeological_area = 0
```

### building

```
building_id = -1
building_type_id = -1
parcel_id = 9551
building_quality_type_id = -1
land_area = 0
non_residential_sqft = 0
residential_units = 0
sqft_per_unit = 0
year_built = -1
zone_id = 35
```



## Step 2: Based on Plan Type, Evaluate Development Constraints

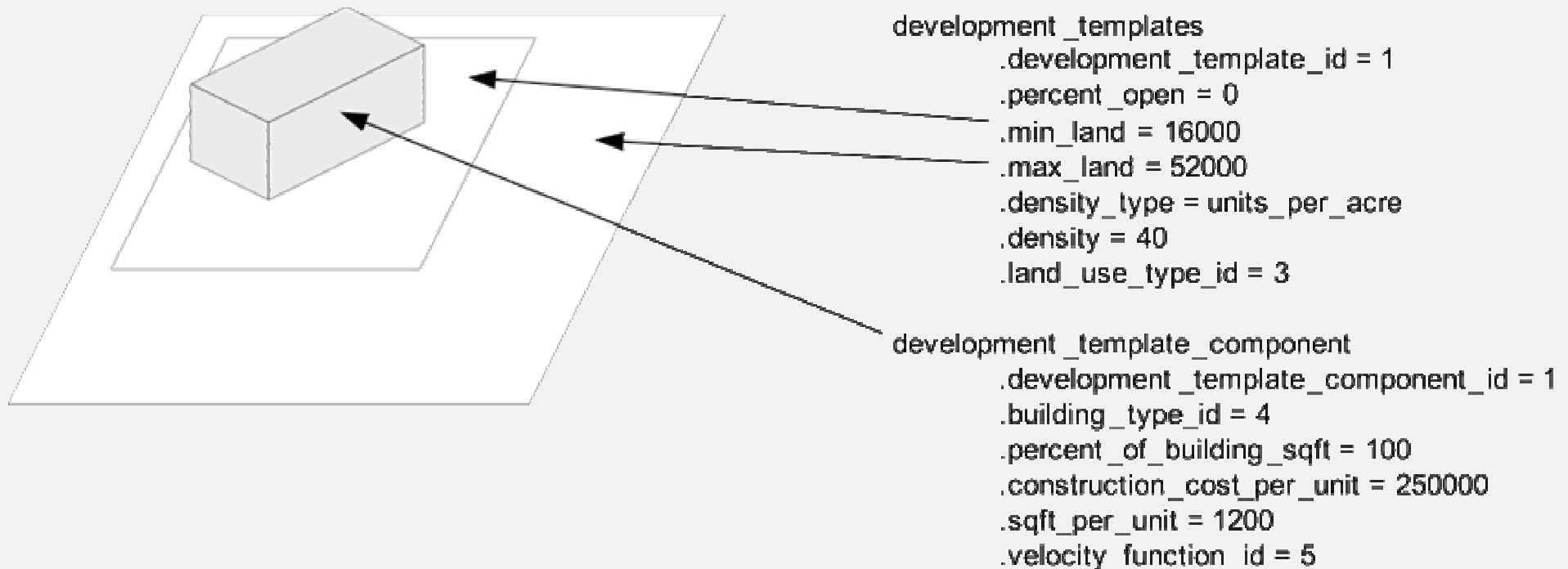
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development\_constraints

.development\_constraint\_id = 46  
.generic\_land\_use\_type\_id = 3  
.plan\_type\_id = 6  
.ownership\_type\_id = 5  
.priority = 1  
.city\_id = 3  
.county\_id = 4  
.constraint\_type = units\_per\_acre  
.minimum = 15  
.maximum = 50  
.is\_in\_floodplain = -1  
.is\_on\_steep\_slope = -1  
.is\_in\_fault\_zone = -1  
.is\_in\_archaeological\_area = -1

# Step 3: Constraints Identify Allowed Development Templates

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Development templates can be defined in a number of different ways, including using the known development projects as the basis, or general plans, or a statistical analysis of recent developments. PSRC project is using the latter approach.

# Step 4: Select Development Proposals to Build

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## AFTER DEVELOPMENT UPDATED FIELDS

parcel

.land\_use\_type\_id = 3

.unit\_price = 251916.62

building

.building\_id = 4587

.building\_type\_id = 4

.building\_quality\_type\_id = 3

.land\_area = 43560

.residential\_units = 40

.sqft\_per\_unit = 1200

.year\_built = 2001

A hedonic price model predicts the price of a post-development proposal on the parcel, and subtracts the predicted cost of site acquisition, and other costs such as site preparation, demolition of existing buildings, extension of infrastructure, financing, and other costs that can be incorporated. This is used to generate an estimate of the Return on Investment (ROI) for each proposal.

Proposals are selected using a probability that is proportional to their expected ROI.

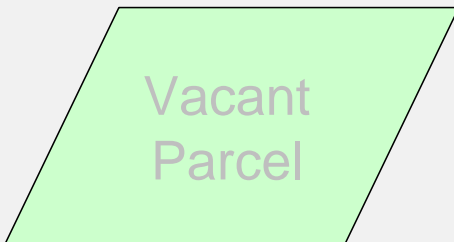
When projects are accepted, they result in Development Projects with status set to 'Active'. These projects are then added by the Building Construction Model.

# Put them all together...

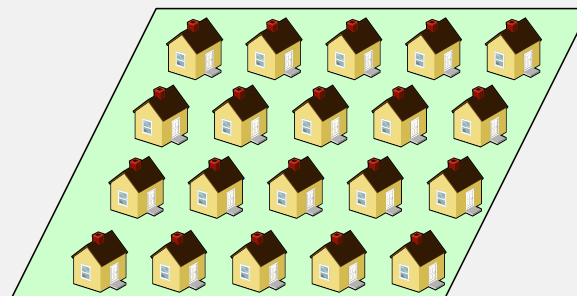
Template #1



Land Use.....	SF Resid
Units Per Acre.....	6
Total Units.....	14
Min Parcel size.....	87,000 SQFT
Max Parcel size....	350,000 SQFT
NPV: .....	\$4,400,000
Costs: .....	\$3,960,000
ROI: .....	11%



Template #2



Land Use.....	SF Resid
Units Per Acre.....	8.5
Total Units.....	20
Min Parcel size.....	87,000 SQFT
Max Parcel size.....	283,000 SQFT
NPV: .....	\$5,360,000
Costs: .....	\$4,700,000
ROI: .....	14%

Medium Density  
SF Residential  
Min units/acre: 4.5  
Max units/acre: 8.7  
2.5 Acres  
107,000 SQFT

# Advantages of Proposal Sampling Model

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- Advances the realism of Real Estate Development Model with parcel geography
- Reconciles landowner and developer perspectives
- Provides a market-based approach that enables:
  - Assessing policies from a market-based perspective
  - Evaluating market-based policies: Impact Fees, Tax Abatement

# Limitation of Proposal Sampling Model

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- Data intensive; parcel-level data, land use regulation, costs data usually not available
- Not amiable to estimation process to recover model parameters

# Peripheral Models

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- Building Construction Model
  - Applying velocity functions to model the timing of real estate development once it is undergoing
- Pre-scheduled Development Events Model
  - Handling pipeline / planned / ongoing projects
- Project Transition Model
  - Determine how much to build for Project Location Choice Model; Sampling projects from development history

# Summary

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	Transition Model	Location Choice Model	Proposal Sampling Model
Decision Makers	Land / Land Owners	Development Projects	financing agents
Alternatives	Land use type; Development type	Location (parcels, gridcells; zones, ... )	Proposals
Constraints	Limiting alternatives	Filtering alternatives to be included	Eliminating Proposals