Santa Monica Mountains Steelhead Habitat Assessment: Watershed Hydrologic Analysis

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Introduction

The primary goal of the watershed analysis was to help identify which basins in the Santa Monica Mountains (SMM) are most capable of supporting steelhead trout populations. This was achieved through 1) an analysis of the relation between baseflow and geology and 2) modeled predictions of rainfall-runoff between the focal watersheds. Such an analysis provides the framework for a decision-making process that can focus restoration efforts towards those watersheds that are most likely to support trout populations.

In the SMM the prediction of hydrologic response to a given rainstorm is difficult due to the lack of gauged basins in the region. The implementation of a mathematical model in the present study allowed the integration of spatial data for a range of watersheds with meteorological data to predict how each watershed would respond to a given rain storm. Results from the hydrologic modeling allow for the ranking of watersheds based on their runoff potential for a given storm. The analysis will assist in the overall prioritization of steelhead habitat restoration for the focal watersheds within the SMM.

Field Setting

Geology of the Santa Monica Mountains

The Santa Monica Mountains are a 70 kilometer long anticlinal uplift with local relief of about 1000 meters (Dibblee, 1982). The mountains are part of an even longer anticlinal uplift zone that extends westward into the Santa Barbara Channel and on to the Channel Islands. The uplift is thought to have resulted from slip on a blind thrust fault called the Channel Islands thrust in the Channels and the Santa Monica thrust on land. Faults of this system are also sometimes known as the Malibu Coastal Fault (MCF).

The zone of east-west faulting in the Santa Monica Mountains divides the range into a western and eastern portion. The western portion is dominated by a mixture of shale (the most common rock) and volcanic rocks. To the east the geology is more complex consisting of a variety of sedimentary rocks including shale, sandstone and conglomerates as well as volcanic rocks. One of the major differences in the eastern section is the presence of several major faults that are strands of the Santa Monica Thrust and/or Malibu Coastal faults. These faults juxtapose a variety of rock types and we believe this faulting plays a significant role in providing baseflow for streams on the eastern portion of the Santa Monica Mountains.

Actual rates of uplift on fault as well as well as lateral fault displacements are relatively low, being less than 1 meter per 1,000 yrs. The coastal marine terrace along the Santa Monica Mountains is believed to be approximately 125,000 years old and it has not been greatly deformed. Nevertheless, the faults have important implications for stream flow.

Hydrogeology

Several streams in the eastern part of the Santa Monica Mountains have summer low flow, which is sometimes referred to as baseflow. In general the occurrence of baseflow is associated with water seeping into the channel providing the summer low flow. In some instances the seepage is rather continuous along the channel as it intercepts the ground water table. In other cases the baseflow may be dominated by a number of "point sources" related to the geologic environment (Keller et al., 1995).

Of particular importance in providing point-sources for baseflow are faults and landslides. Of these, faults are probably the most important process. Faults juxtapose rocks of varying type and also provide a subsurface dam composed of crushed rock with clay that ponds groundwater. If an aquifer is faulted against a downstream fault then water is forced to the surface forming a series of springs that provides baseflow. Landslides can yield baseflow because they generally are more porous than the bedrock they slide from and they store the water that is released during the summer low flow periods.

Methods

Conceptual Model

Runoff Generation

When rain falls on the ground surface there are several possible paths that it can take before contributing to storm runoff. If water travels directly down a hillslope with little infiltration it is usually termed storm runoff. Water that percolates into the soil moves at much slower velocities and reaches the stream over longer time periods. This type of flow is typically referred to as baseflow (Dunne and Leopold, 1978). Both storm flow and baseflow are important to steelhead during different stages of their life cycle.

Baseflow

Baseflow is likely to be the limiting factor for steelhead during the summer moths when the majority of the channel is dry. During these conditions the majority of the habitat is restricted to isolated pools or reaches of water that remain wet all year. We suspect that these wet and dry regions correspond to geologic factors, including faulting and the type of rock present.

Favorable conditions for promoting wet reaches include; 1) the presence of bedrock units, such as sandstone and conglomerate which are aquifers; 2) faulting which forces water to the surface and 3) the presence of landslide deposits which store groundwater near the surface. In general, shale or highly fractured igneous rocks do not store significant amounts of water and streams flowing over these units may dry up during the summer. In order to determine where the wet areas were likely to be found we analyzed geologic maps for the presence of these three primary factors thought to be important in maintaining baseflow. The field data on the total length of stream that was wet during the summer dry months (as a percentage of total stream length surveyed) was compared to the presence or absence of these geologic factors.

Stormflow

Stormflow plays a larger role during the wet months of the year when sufficient flow is necessary for steelhead migration to and from the coastal region. Considering the watershed characteristics (land use, soil and slope) as well as the climate, the dominant runoff pathways during storms should be as Hortonian overland flow. Hortonian overland flow occurs when rainfall intensity exceeds the infiltration rate. This type of runoff is common in semi-arid areas with poorly drained soils and flashy hydrologic response. Subsurface storm flow and saturation overland flow also contribute but should not be as significant. Baseflow is considered to be a small fraction of storm runoff.

With this conceptual model of runoff in mind, the Hydrologic Modeling System (HEC-HMS) model was used to predict rainfall-runoff trends for the focal watersheds in the study area (US Army Corps of Engineers, 2000). The model input data was collected for calibration and validation of the predictions. Precipitation and runoff data from Topanga Creek watershed was used to calibrate the model and test the goodness of fit between measured and predicted discharge. Once the model had been calibrated, simulations were performed for the other focal watersheds.

Data

The data required for developing the model included: 1) precipitation; 2) runoff; 3) land use; 4) topography; and 5) soil data.

Precipitation

Precipitation data from the Los Angeles International Airport (National Climate Data Center, 2001) was used in conjunction with rainfall data from Topanga Canyon Patrol Station (Reagan, 2004). There is a well-developed spatial gradient in rainfall in the SMM due to the topographic influence (Figure 1 on the previous page). In order to account for the influence of topography on precipitation, measured 60-year rainfall data on the mean annual rainfall (California Department of Forestry and Fire Protection, 2000) was used to extrapolate precipitation values to unmonitored basins.

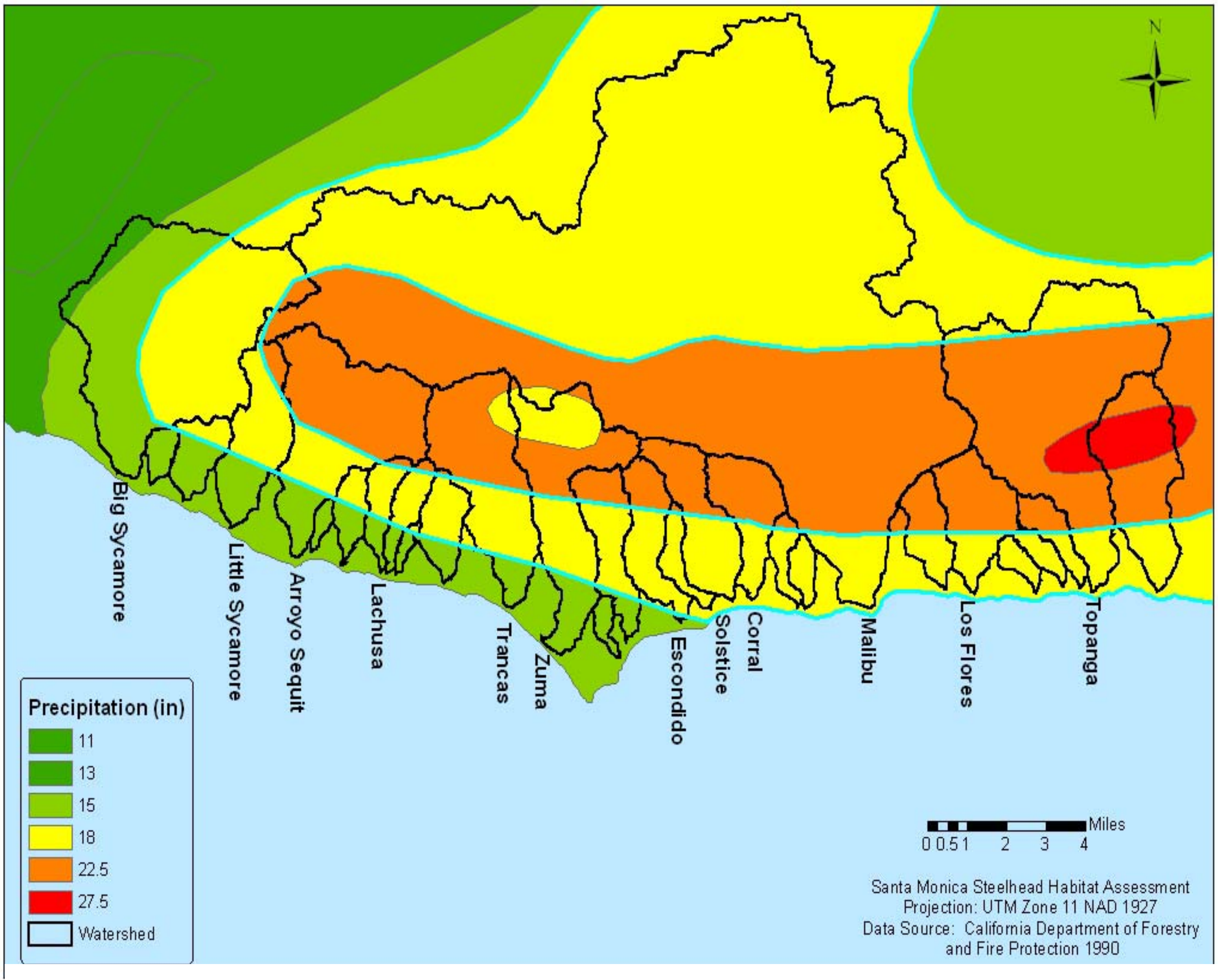

Figure 1. Mean annual precipitation for the SMM (*source*: California Department of Forestry and Fire Protection, 1990).

Discharge

Measured 60-minute discharge data from Topanga Creek above the mouth of the canyon was used for the water years of 1996-1997, 1997-1998 and 1998-1999 (Los Angeles Department of Water and Power, 2004 and Reagan, 2004). The gage is located 2.0 miles north of Topanga Beach. The discharge data was selected to represent mean, dry and wet hydrologic conditions. Based on precipitation data from LAX from the years of 1969-2000, the mean annual rainfall was recorded as approximately 13.5 inches per year. During the water year 1996-1997 the rain gage at LAX received 13.3 inches and was thus selected as being representative of a typical rain year. The water year of 1997-1998 was one of the highest on recent record with approximately 31.0 inches of rainfall and was chosen to represent wetter than average conditions. During the 1998-1999 water year the rain gage at LAX received 9.26 inches of rain and was thus selected to represent drier than average conditions.

Land Use

Land use data developed using 1-meter digital aerial imagery was acquired from the Southern California Association of Governments (Southern California Association of Governments, 2000). The 30 original land use classes were aggregated into 7 primary categories (table 1 in the appendix). The major classes are agricultural, industrial, open space, high density residential, low density residential, mixed urban and commercial. These classes were used to determine the extent of imperviousness in each watershed. Figure 2 below shows the land use distribution for the SMM.

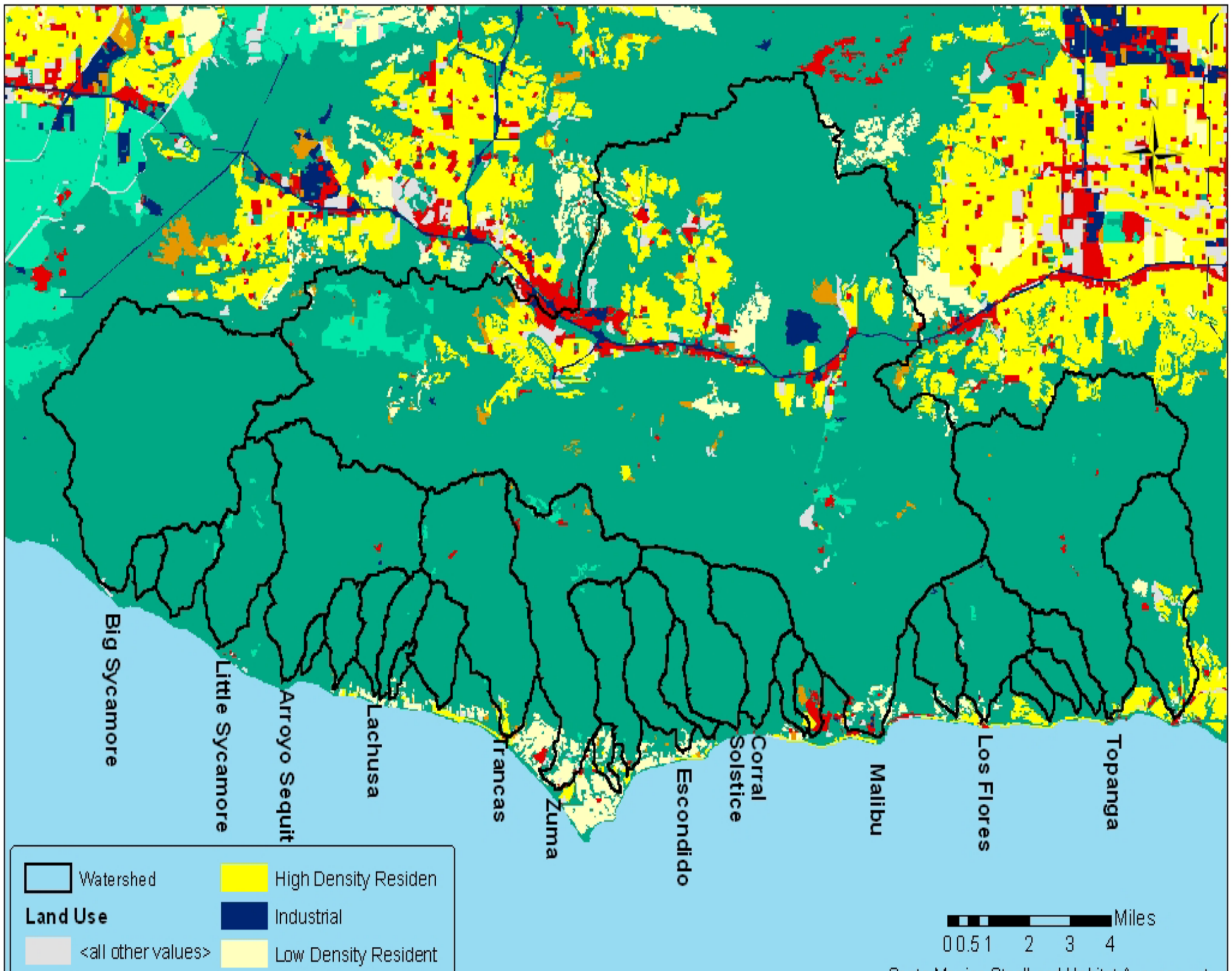

Figure 2. Land use classes for the SMM (*source*: Southern California Association of Governments, 2000).

Topography

A 10 meter digital elevation model (DEM) developed by the U.S. Geological Survey was used for the entire study region (Figure 3). The data was projected in UTM zone 11 using NAD1927 datum.

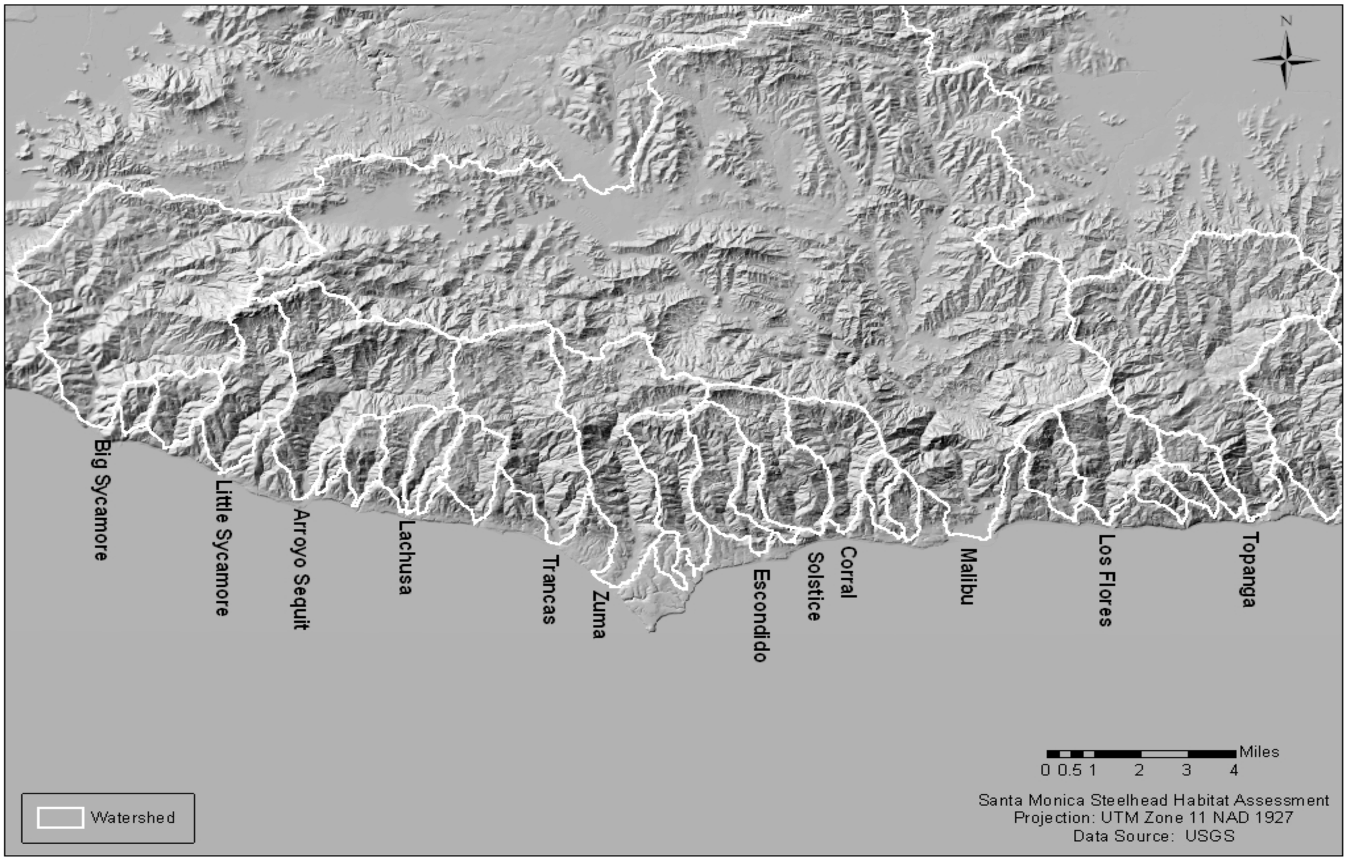

Figure 3. Digital Elevation Model of the focal watersheds (*source*: US Geological Survey).

Soil Hydrologic Group

The State Soil Geographic (STATSGO) data was used to characterize the soil of the region (Natural Resources Conservation Service, 2000). These data files were digital line graphs that could be overlain on the watershed boundaries to determine soil types within each basin. Group D, which comprises poorly drained soil is the dominant hydrologic group in this region.

Model Development

Watershed Delineation and Terrain Processing

After completion of the data assembly, HEC-GeoHMS v. 1.1 (US Army Corps of Engineers, 2003) was used to process the terrain and spatial information to generate hydrologic inputs for HEC-HMS. HEC-GeoHMS is an extension of ArcView 3.2 that allows for the development of an initial HMS model. Using the DEM as input, the terrain processing involves a series of steps to derive the drainage networks. The steps consist of computing the flow direction, flow accumulation, stream definition, watershed delineation, watershed polygon processing, stream processing, and watershed aggregation. Delineation of the stream and sub-basins provides the physical characteristics such as drainage area, river length, slope, longest flow path, basin centroid and centroidal flow path. These physical parameters were derived based on stream and watershed characteristics, gaged precipitation and stream flow data. The basin model for Topanga Canyon derived in HEC-GeoHMS is shown as figure 4 below.

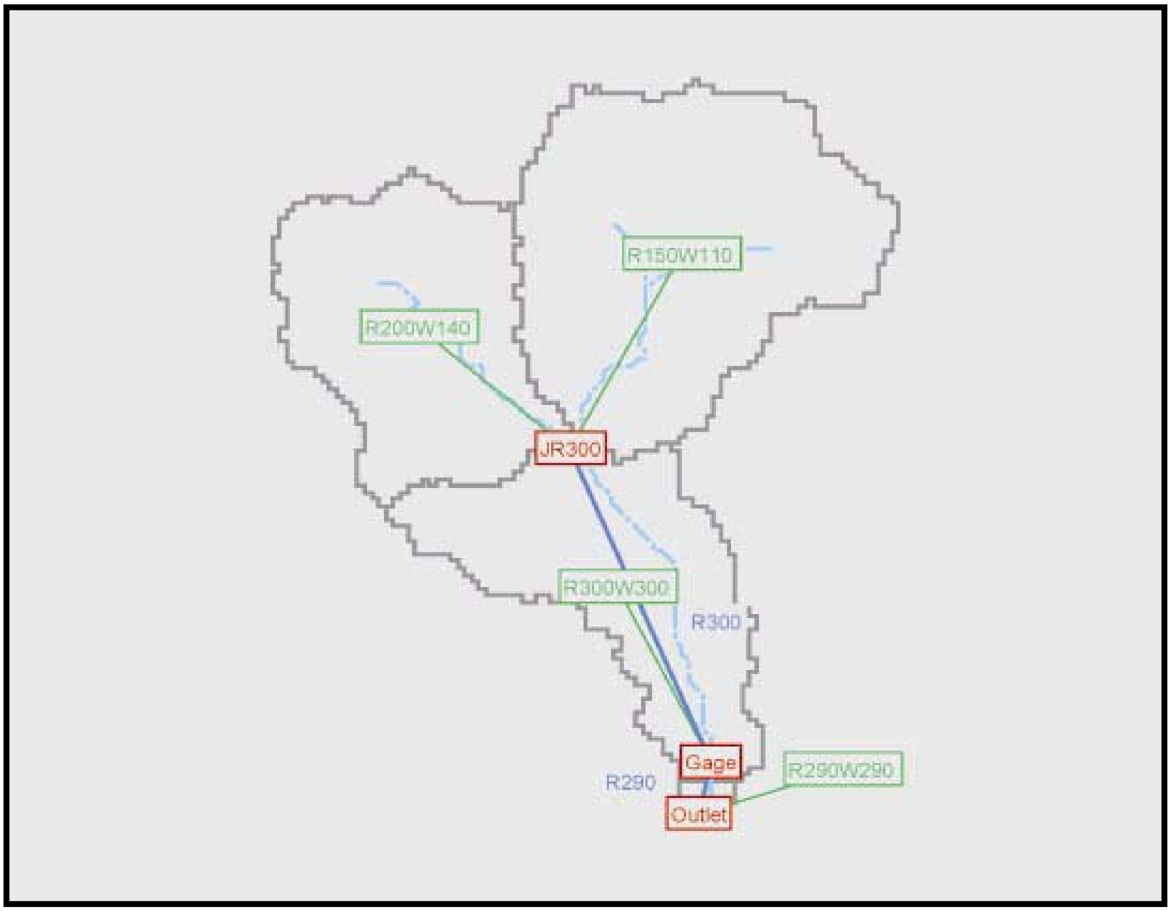

Figure 4. Watershed schematic of Topanga Canyon.

The watershed was delineated into three sub-basins with three reaches and one primary junction (Figure 4). The physical characteristics of the stream networks and sub-basins derived in HEC-GeoHMS were imported directly into HEC-HMS to perform the rainfall-runoff calculations.

Precipitation Modeling

Storm hydrographs were produced for each basin over a given time period, typically 1 month in duration. We used the isohyetal data on mean annual precipitation (Figure 1) to create an area-based weighting scheme. An isohyetal is simply a contour line of equal precipitation that is estimated from point measurements. We used data from the Topanga Patrol Station as point of reference for all the other basins. The rain gage is located at coordinates of 34-05-03 latitude and 118-35-57 longitude. Rainfall input values for each basin were scaled based on the percentage of rainfall received relative to the Topanga Patrol Station. The weighted precipitation values were input into each sub-basin in order to correctly capture the existing precipitation gradient in the range.

Runoff loss method

HEC-HMS considers that all land and water in a watershed can be categorized as either pervious or impervious surfaces. Impervious surface implies that when rain falls on the surface no water infiltrates or evaporates and the entire volume contributes to direct runoff. Precipitation on pervious surfaces is subject to losses, thus an estimate of the initial abstraction rate is required, where the initial abstraction is the loss of water due to infiltration during a storm event.

We use the Soil Conservation Service (SCS) curve number (CN) model to account for losses due to variation in soil cover, land use and antecedent moisture. The SCS curve number model is a well-established fairly simple method and the curve numbers can be estimated from tables (Dingman, 2002). We use a weighted-average curve number for each sub-basin to correctly account for small-scale variation in physical parameters. CN values range from 100 (for water bodies) to approximately 30 for permeable soils with high infiltration rates. The range in SCS curve numbers was fairly small between basins as the SMM consist of primarily open space with poorly drained soils. Typical values can be found in table 2 in the appendix.

From analysis of results from many small watersheds, the SCS developed the empirical relationship of the initial abstraction based on the potential maximum retention, which is a measure of a watershed to abstract and retain storm precipitation. Equation 1 gives the empirical relation for the initial abstraction I_a:

$$I_a = 0.2 * S_{max} \tag{1}$$

The maximum retention, S_{max}, is related to the watershed characteristics through the curve number (CN) as given by equation 2:

$$S_{\max} = \left[\frac{1000 - 10CN}{CN} \right] \tag{2}$$

Runoff Modeling

We use the SCS unit hydrograph method to model the direct runoff (Soil Conservation Service, 1986), which is based upon user-defined gaged rainfall and runoff data. The key parameter is the basin lag, defined as the difference between the center of mass of rainfall excess and the peak of the unit hydrograph. The basic method involves estimating the lag-to-peak time as a function of the basin area. An empirical equation (Kirkby, 1978) developed from field data from small basins where Horton overland flow is known to be the dominant runoff pathway was used to estimate the basin lag time (L_c):

$$L_c = 1.06 * A^{0.14} \tag{3}$$

Where L_c = basin lag (hours) and A = basin area (mi^2). Typical values are given in table 2 in the appendix.

Baseflow Model

Due to insufficient data, we assume no baseflow in this study. While this is a limitation in determining summer low flow conditions, when making storm runoff calculations baseflow is of less importance.

Model Calibration

Selection of model parameters involves estimations based on watershed properties, thus calibration is often required to bring simulated values into agreement with the predictions. The calibration step used observed hydrometeorological data to yield the best fit of computed to observed runoff values. The basic data required using HEC-HMS are rainfall and discharge data.

The model was calibrated using stream flow data from Topanga Canyon at the gage located near the mouth of the canyon. The stream flow gage (station code F54C-R) drains approximately 18 square miles of the watershed. The Topanga Patrol Station (station ID 6) gage is located in the central portion of the basin at an elevation of 745 feet.

The rainfall and stream flow selected was from the month of January 1997. This period had two distinct storms spaced out over a two week period, thus we could easily test the observed vs. predicted runoff values. Model calibration was performed using the HEC-HMS optimization system, which allowed for comparison of simulated versus measured runoff values. The model was then tested for goodness-of-fit by comparing predicted and observed runoff values for a moderate rain season (water year 1999) and a wet year (water year 1998).

Results

Model Application

The calibrated model was applied to the focal watersheds in the SMM to estimate rainfall-runoff trends. Long-term rainfall analysis was based on over 30 years of rainfall data at LAX. Simulations were made for the mean year (1997) and a relatively wet (1998) and moderate year (1999).

Calibration

The Topanga Creek predictions matched well with the observed data. Model parameters were optimized to reflect flows observed throughout the simulation period.

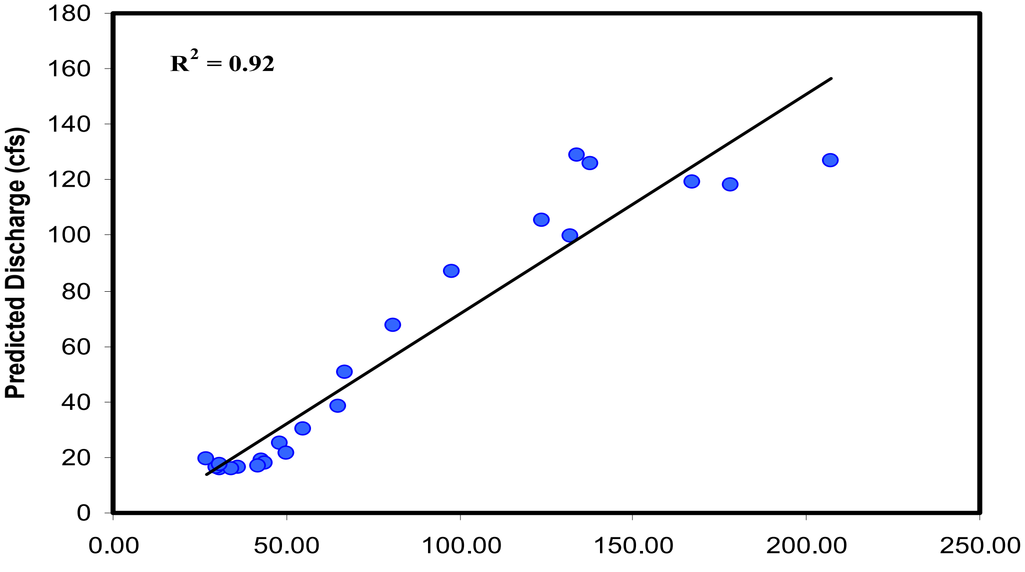

Figure 5. Measured vs. predicted discharge values for Topanga Creek, January 1997.

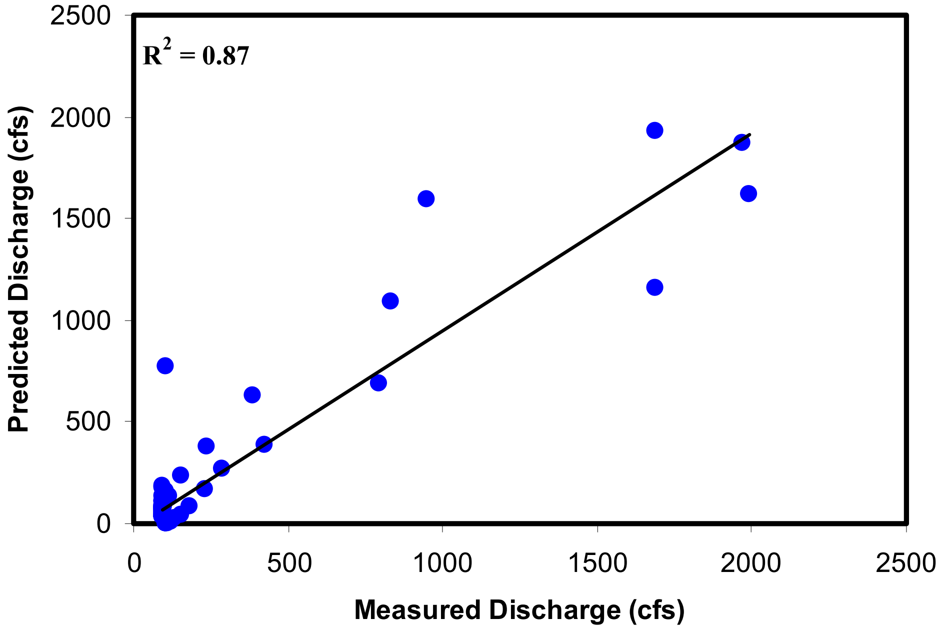

Figure 6. Measured vs. predicted discharge for Topanga Creek, February, 1998.

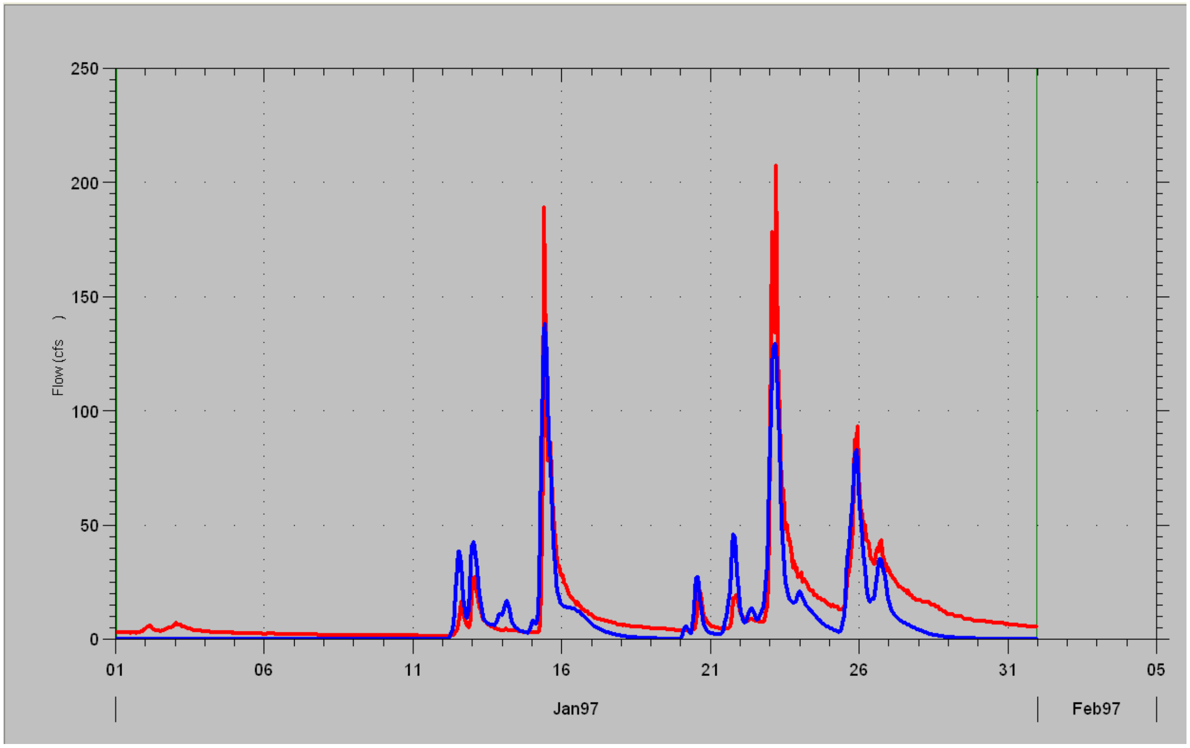

Figure 7. Time-series data showing the observed (red line) vs. predicted (blue line) discharge values at the Topanga Gauge outlet during January 1997.

Model predictions were typically more accurate for lower discharges, below 1000 cfs. The model was able to reproduce the timing of peak discharges well by identifying both the daily hydrograph shape and the peak flow values, though the peak values were often underestimated. Because the discrepancy is primarily in the peak values, it is likely that the initial abstraction is slightly under-predicted. Model estimates of runoff volume were within 5-10% of the observed values.

Watershed Application

In order to determine the runoff potential between watersheds rainfall-runoff simulations were conducted for the focal watersheds. Results are shown in tables 3 and 4 below.

Table 3. Runoff predictions under heavy rain conditions (97-98 water year).

	Area (mi^2)	Peak Discharge (cfs)	Volume (ac-ft)
Malibu	109.59	19156.00	75740.00
Topanga	19.51	3318.40	13622.00
Arroyo Sequin	10.92	2845.30	8140.90
Trancas	8.45	2117.00	6117.30
Big Sycamore	21.00	1624.60	10807.00
Zuma	8.91	1615.20	5888.80
Los Flores	4.14	1045.80	3166.50
Solstice	4.31	909.87	3472.30
Escondido	4.31	889.49	3535.10
Corral	3.62	780.31	2918.40
Little Sycamore	4.85	700.70	2440.70
Encinal	2.08	415.99	1294.77
Lachusa	1.42	258.66	855.54

Table 4. Runoff predictions for the moderate storm conditions (98-99 water year).

	Area (mi^2)	Peak Discharge (cfs)	Volume (ac-ft)
Malibu	109.59	7825.20	36774.00
Topanga	19.51	1361.00	8232.00
Arroyo Sequit	10.92	1207.60	3803.50
Trancas	8.45	876.54	2863.70
Big Sycamore	21.00	698.55	5576.80
Zuma	8.91	640.78	2773.00
Los Flores	4.14	426.59	1509.70
Little Sycamore	4.85	383.73	1318.70
Solstice	4.31	364.25	1649.80
Escondido	4.31	358.85	1700.50
Corral	3.62	317.17	1383.80
Encinal	2.08	185.16	750.76
Lachusa	1.42	108.27	403.80

In general the peak runoff values are largely a function of the drainage area with the larger basins producing higher peak flows during the same storms (Figure 8 below). The one exception to this rule appears to Big Sycamore, which has the second largest watershed area yet produces the fifth largest peak flow values. This anomaly is likely due to the precipitation gradient found in the range with the eastern basins receiving more annual rainfall. Field evidence has found that several deep pools exist in this basin yet they are limited to the northeastern portion of the watershed where higher annual rainfall is received.

The precipitation gradient has a greater impact on runoff values during the larger storms as seen in the wet year simulation (Table 3). In these simulations Little Sycamore produced less runoff and lower peak flow than four smaller basins.

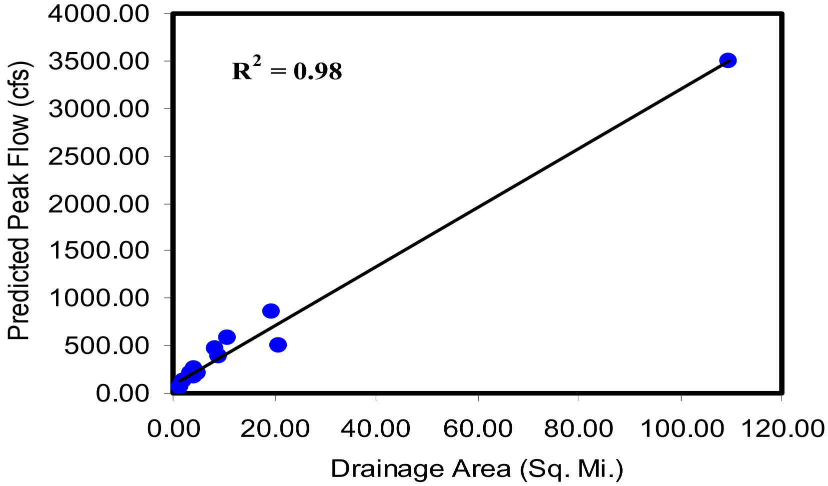

Figure 8. Drainage area vs. predicted peak flow.

The lag time also showed a strong dependence on drainage area, where smaller watersheds had shorter lag times (Figure 9). This is important with respect to steelhead migration opportunities, which is likely limited in the smaller basins to less than a few hours of adequate flow conditions. This trend is especially important during low water years when the window of opportunity for steelhead migration is further reduced.

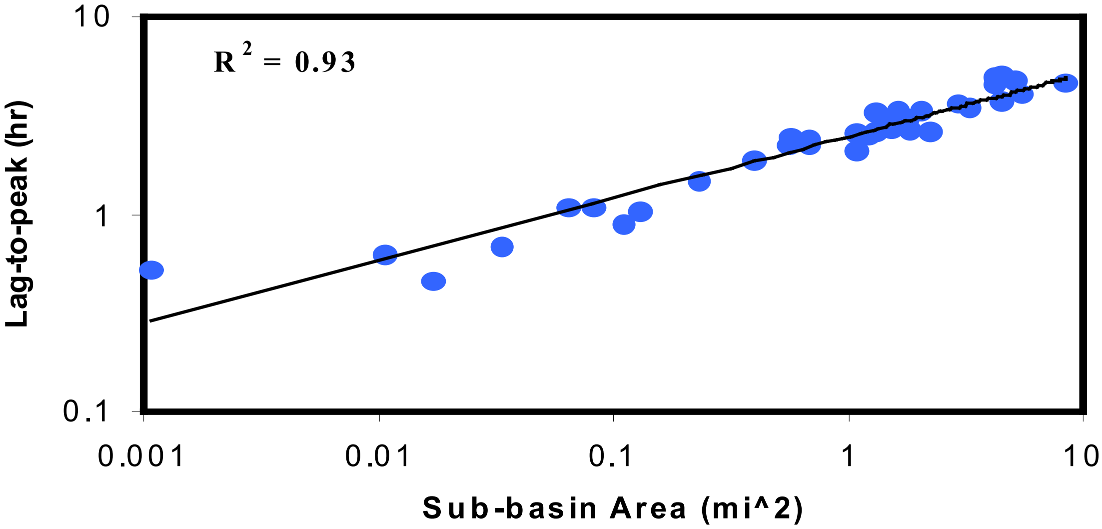

Figure 9. Sub-basin area vs. lag-to-peak.

Baseflow

Examination of Table 5 suggests the role of faulting and land sliding is contributing to the baseflow in the Santa Monica Mountains. Those streams with the most persistent baseflow are associated with the Santa Monica thrust and Malibu Coast faults. Additional work is necessary to confirm that springs in fact are present. However the fact that the steams with most persistent summer low flow are those that are associated with the faulting and land sliding strongly suggest the geologic control as the dominant positive factor.

Table 5. Relation between general geology and summer low flow conditions.

Watershed	Total Stream Length Surveyed (m)	% Wet	General Geology
Big Sycamore	13118	2	Mostly shale
Little Sycamore	5037	40	Mostly shales in the lower region and volcanics in the upper region
Arroyo Sequit	5465.4	21	Shale
Arroyo Sequit-East	863	15	Shale
Encinal	1492	92	Alluvium lower 600 m, landslides; crosses MCF at 600 m and 1.7 km.
Trancas	4441	74	Sespe conglomerate formation, lots of alluvium in lower 2 km; crosses Malibu Coast Fault (MCF) at 1 km.
Zuma	7097	23	Good gravel and aquifer units in the lower 3 km; crosses two branches of the MCF in lower 3km and the Latigo fault at 0.7 km.
Escondio	3657.5	49	Lower 1.5 km has good geology, upper portion mostly shale; crosses MCF at 400 m and 1 km.
Corral	1662	67	Stream crosses 4 large landslides, primarily Monterey shale and sandstone; crosses MCF at 250 m.
Las Flores	3801.5	93	3 landslides in lower regions, Conejo volcanics; crosses Las Flores fault at 0.9 km and 1.5 km and another unnamed fault at 2.2 km

Discussion and Conclusions

Geology and Baseflow

Watershed characteristics and channel morphology are a function of geologic and climatic controls. In the SMM, the geology was found to be an important factor in enhancing the presence of summer low flow habitat, which is perhaps the major limiting factor in southern California streams. Where aquifers are present and the groundwater is forced to the surface due to the existence of steep faults, seeps and springs are more common. The presence of rocks with low hydraulic conductivity and an absence of faulting appear to lead to little or no baseflow. On a regional scale, the eastern portion of the SMM likely offers a higher potential for summer low flow due to the more favorable geology.

In terms of available fish habitat, Encinal, Trancas, Corral and Las Flores all demonstrated extensive wet regions and would likely provide important refuge during the dry summer months. Escondido and Little Sycamore also had potential in terms of providing low flow habitat with approximately 49 and 40 percent of the channel being wet during the dry months, respectively. Further comparison and ranking of the quality of fish habitat among basins will be elucidated through analysis of the existing field data.

Runoff Modeling

The HEC-HMS model was successfully applied to the focal watersheds of the SMM. Although the model was able to re-create peak flows and runoff volumes well during most simulations it had trouble during times of extended rainfall. This could be due to the fact that the SCS model does not take temporal variability of soil moisture into account. Thus when antecedent moisture conditions are high the default values for the initial abstraction may be too low. This can be overcome by modeling single storms and using intuition about the soil moisture when adjusting the initial abstraction values.

In southern California there is a distinctive wet season that accounts for the majority of the rainfall. Thus the present analysis focused on modeling storm runoff during the wet season and did not attempt to model dry weather flow conditions. Future modeling studies on the limiting factors for steelhead would be greatly improved by collecting region-wide baseflow data to include in storm run-off conditions and summer low flow predictions. These predictions would also be enhanced through greater spatial representation of discharge gages in the SMM.

The overall results of the modeling produced a general ranking of the watersheds based on the peak and volumetric flow estimates. These values were both tightly coupled with the drainage area with larger basins in general producing higher flows that were sustained over longer time periods. Based on storm flow modeling results, future restoration efforts should be focused on Malibu, Topanga, Arroyo Sequit, Trancas, Zuma, and Las Flores.

Differentiating between the smaller basins can be accomplished by considering the precipitation gradient in the region as well as the presence of baseflow during the summer months. Both the precipitation gradient and the geology contribute to creating better habitat in the eastern portion of the SMM. Future planning on where to focus restoration efforts should give consideration to these climatic and geologic factors.

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Technical Appendix

Table 1. Land use aggregation for the SMM watersheds.

Original Land Use Code	Land Use Group	Original Land Use Code	Land Use Group
Abandoned Orchards and Vineyards	Agriculture	Trailer Parks and Mobile Home Courts, High-Density	High Density Residential
Irrigated Cropland and Improved Pasture Land	Agriculture	High-Density Single Family Residential	High Density Residential
Non-Irrigated Cropland and Improved Pasture Land	Agriculture	Medium-Rise Apartments and Condominiums	High Density Residential
'Orchards and Vineyards	Agriculture	Low-Density Single Family Residential	Low Density Residential
Other Agriculture	Agriculture	Under Construction	Mixed Urban
Manufacturing, Assembly, and Industrial Services	Industrial	Mixed Commercial and Industrial	Mixed Urban
Communication Facilities	Industrial	Wholesaling and Warehousing	Commercial
Marina Water Facilities	Industrial	Colleges and Universities	Commercial
Maintenance Yards	Industrial	Commercial Recreation	Commercial
'Mixed Transportation and Utility	Industrial	Commercial Storage	Commercial
Mineral Extraction - Other Than Oil and Gas	Industrial	Elementary Schools	Commercial
Bus Terminals and Yards	Industrial	Correctional Facilities	Commercial
Freeways and Major Roads	Industrial	Hotels and Motels	Commercial
Solid Waste Disposal Facilities	Industrial	Junior or Intermediate High Schools	Commercial
Electrical Power Facilities	Industrial	Low- and Medium-Rise Major Office Use	Commercial
Liquid Waste Disposal Facilities	Industrial	Major Medical Health Care Facilities	Commercial
Beach Parks	Open	Modern Strip Development	Commercial
Beaches (Vacant)	Open	Older Strip Development	Commercial
Developed Local Parks and Recreation	Open	Open Storage	Commercial
Horse Ranches	Open	Other Special Use Facilities	Commercial
Other Open Space and Recreation	Open	Other Public Facilities	Commercial
Rural Residential, High-Density	Open	Police and Sheriff Stations	Commercial
Rural Residential, Low-Density	Open	Pre-Schools/Day Care Centers	Commercial
Undeveloped Regional Parks and Recreation	Open	Religious Facilities	Commercial
Vacant Undifferentiated	Open	Research and Development	Commercial
Wildlife Preserves and Sanctuaries	Open	Retail Centers (Non-Strip With Contiguous Interconnected Off-Street	Commercial
Golf Courses	Open	Senior High Schools	Commercial
Vacant With Limited Improvements	Open	Special Care Facilities	Commercial
Water, Undifferentiated	Open	Water Storage Facilities	Commercial
Duplexes, Triplexes and 2-or 3-Unit Condominiums and Townhouses	High Density Residential		

Table 2. Model parameters utilized in HEC-HMS modeling**.**

Basin Name	Initial Abstraction (in)	Soil Conservation Service (SCS) Lag Time (hrs)	Soil Conservation Service (SCS) Curve Number
Malibu			
R1950W370	0.40	1.80	83.30
R1560W580	0.40	1.81	83.47
R1770W1250	0.29	1.93	87.24
R1880W1780	0.55	1.47	78.46
R2200W1930	0.56	1.43	78.20
R2060W1900	0.53	1.54	79.11
R1930W1940	0.58	1.30	77.60
Topanga			
R150W110	0.56	1.56	78.19
R200W140	0.56	1.46	78.01
R290W290	0.49	0.87	80.47
R300W300	0.56	1.45	78.14
Arroyo Sequit			
R680W460	0.57	1.36	77.86
R760W590	0.56	1.42	78.18
R770W770	0.60	0.79	77.02
R810W780	0.57	1.34	77.77
Trancas			
R750W560	0.58	1.29	77.59
R730W730	0.58	1.23	77.40
R1040W1030	0.59	1.09	77.18
R860W860	0.58	1.25	77.46
R1060W1060	0.59	1.20	77.34
R1100W1100	0.59	1.06	77.15
R1140W1140	0.60	0.65	77.00
R1150W1150	0.60	0.94	77.06
Big Sycamore			
R480W150	0.57	1.33	77.74
R600W160	0.51	1.59	79.56
R730W540	0.58	1.31	77.64
R880W700	0.56	1.41	78.11
R920W920	0.60	0.84	77.03
R930W930	0.59	1.20	77.36
Zuma			
R830W810	0.59	1.19	77.32
R870W620	0.58	1.24	77.43
R850W850	0.58	1.22	77.39
R900W900	0.60	0.61	77.00
R910W910	0.56	1.42	78.17
Los Flores			
R370W370	0.56	1.26	77.99
R410W410	0.53	0.69	79.14
R420W420	0.58	1.17	77.53
R430W430	0.58	1.17	77.58
Solstice			
R340W340	0.58	0.72	77.44
R350W350	0.59	1.41	77.35
Escondido			
R400W400	0.60	0.44	77.00
R410W410	0.57	1.41	77.92
Corral			
R350W350	0.57	1.38	77.94
Little Sycamore			
R140W70	0.59	1.07	77.15
R90W90	0.59	1.09	77.18
R310W240	0.59	1.17	77.29
R320W320	0.59	1.01	77.10
R600W360	0.58	1.28	77.54
Lachusa			
R920W920	0.60	0.81	77.02
R930W930	0.59	1.20	77.35