**Barton Springs rangeland/pastureland**

This scenario has been parameterized to represent pesticide application on pastures, grassland, and rangeland in the Barton Springs Segment (BSS) of the Edwards Aquifer. Vegetation is generally dominated by grasses, forbs and shrubs. In North America, rangelands include the grasslands of the Great Plains including Midwestern United States to Manitoba, Saskatchewan, and Alberta in Canada. Other types of rangelands include US wetlands, Texas and Florida savannas, western US shrublands, Alaskan and Canadian tundra, Mexican deserts, and alpine meadows in mountain ranges throughout the North American continent (SRM 2004).

In the BSS, rangeland vegetation is a heterogeneous mixture of trees and grasses. Common tree species include: ash juniper (a nuisance species), oaks, hackberry and elms. Grass species including little blue stem, side oats gramma, indian grass, switch grass, king ranch bluestem (introduced) and kline grass (introduced) are typical. These areas are composed of approximately 60-65% trees and 30-35% grasses (Perez 2006). Although these landcovers contain a significant amount of tree cover, this "crop" was modeled as a field crop rather than an orchard in order to model a more conservative field.

Soils were selected based on their extent within the natural herbaceous land cover in BSS and the potential to yield high-end runoff and erosion. Based on a geospatial analysis of soils (USDA 2006) and land use data (USGS 2003) for natural herbaceous areas as well as conversations with local soil experts, Brackett soils were chosen to represent rangeland/pastureland areas in the BSS (Table 5). Brackett soils are found in both the contributing and recharge zones of the Edwards Aquifer and are the most common soil on which rangeland is located (USDA 2006; USGS 2003). Location of the Brackett soils was also cross-checked with aerial photography to ensure that the soil chosen coincided with natural herbaceous areas where pesticides may be applied. According to a local extension agent (Cris Perez), rangelands reside on a variety of soils; however Brackett is a common soil type of rangelands in the BSS.

The Brackett series was selected for this scenario because it is both highly representative of rangeland/pastureland areas in the BSS and because it represents the 90$^{th}$ percentile of vulnerability, drainage, erodibility, and slope. The Brackett series is a Hydrologic Group C soil which account for 23% of all soils in rangeland areas (Table 5). Hydrologic Group C soils account for approximately 49% of natural herbaceous soils in drainage. These soils are loamy, carbonatic, thermic, shallow Typic Haplustepts which consist of very shallow to shallow soils over bedrock. These well drained and moderately permeable soils formed in residuum over chalky limestone bedrock (USDA 2001). Brackett soils have a USLE K factor of 0.37 which includes the 90$^{th}$ percentile of these soils in erodibility (Table 5). Slopes range from 1 to 60 percent (Soil Survey Staff, 2006); however the most typical range for the Brackett series in rangeland areas is 1-8 percent (USDA 2006; USGS 2003). Soil parameters for the "Brackett-Rock outcrop-Comfort complex, 1 to 8 percent slopes" were selected from Soil Data Mart to parameterize this scenario since this soil type is the most extensive soil co-occuring with

rangeland/pastureland within the Brackett series (USDA 2006; USGS 2003). Data from Hays County were selected since the majority of this landcover is located in this county.

The meteorological station selected for this scenario is located in Austin, Texas. This station is the closest available weather station that includes data required for PRZM.

**Table 1. PRZM 3.12 Climate and Time Parameters for Barton Springs, TX.**

| Parameter | Value | Source/Comments |
|---|---|---|
| Starting Date | Jan. 1, 1961 | Meteorological File from Austin, TX (W13958) |
| Ending Date | Dec. 31, 1990 | Meteorological File from Austin, TX (W13958) |
| Pan Evaporation Factor (PFAC) | 0.69 | PRZM Manual Figure 5.1 (EPA 1998). |
| Snowmelt Factor (SFAC) | 0.36 | PRZM Manual, Table 5.1 (EPA 1998). |
| Minimum Depth of Evaporation (ANETD) | 25 | Mid point of range (20-30), PRZM Manual, Figure 5.2 (EPA 1998). |

**Table 2. PRZM 3.12 Erosion and Landscape Parameters for Barton Springs - rangeland/pastureland.**

| Parameter | Value | Source/Comments |
|---|---|---|
| Method to Calculate Erosion (ERFLAG) | 4 (MUSS) | Default value. |
| USLE K Factor (USLEK) | 0.37 tons $EI^{-1}$* | NRCS Soil Data Mart Database, Hays County, for Brackett-Rock outcrop-Comfort complex, 1 to 8 percent slopes. (http://soildatamart.nrcs.usda.gov/). |
| USLE LS Factor (USLELS) | 0.69 | Calculated according to Haan and Barfield (1978) equation: $LS = ((\lambda/72.6)^m)((430x^2 + 30x + 0.43)/6.613)$, where $\lambda$ = slope length, x = SLP/100 and m = constant. In this case, $\lambda$ = 400 m (default value) and m = 0.4 (EPA 2004). |
| USLE P Factor (USLEP) | 1 | No contour plowing is expected (EPA 2004). |
| Field Area (AFIELD) | 10 ha | Default drainage area for standard ecological pond (EPA, 2004). |
| NRCS Hyetograph (IREG) | 4 | PRZM Manual, Figure 5.12 (EPA, 1998). |
| Slope (SLP) | 4 % | Brackett-Rock Outcrop-Comfort Complex Soil Slope range 1-8% (USDA 2006). Midpoint of slope range (EPA, 2004) |
| Hydraulic Length (HL) | 356 m | Default value for standard ecological pond (EPA, 2004) |
| Irrigation Flag (IRFLAG) | 0 | Cris Perez, NRCS - District Conservationist<br>Date: 3-16-06, Phone: 512-392-4050 x3 |
| * EI = 100 ft-tons * in/ acre*hr | | |

| Table 3. PRZM 3.12 Crop Parameters for Barton Springs - rangeland/pastureland. | | |
|---|---|---|
| **Parameter** | **Value** | **Source/Comments** |
| Initial Crop (INICRP) | 1 | Default value |
| Initial Surface Condition (ISCOND) | 3 | Cris Perez, NRCS - District Conservationist<br>Date: 3-16-06, Phone: 512-392-4050 x3 |
| Number of Different Crops (NDC) | 1 | Set to number of crops in simulation. Default value. |
| Number of Cropping Periods (NCPDS) | 30 | Set to weather data in meteorological file: Austin, TX (W13958). |
| Maximum rainfall interception storage of crop (CINTCP) | 0.2 | At their maximum growth, grasses may intercept as much as 20% of gross precipitation during individual storms (Dunne and Leopold, 1978). |
| Maximum Active Root Depth (AMXDR) | 43 cm | Cris Perez, NRCS - District Conservationist; Date: 3-16-06, Phone: 512-392-4050 x3<br>Root depth depends upon the soil depth. In creek beds, grass roots will grow 3-4'. On rolling hills, they will grow 6-8". Therefore, this value set to CORED. |
| Maximum Canopy Coverage (COVMAX) | 97% | Cris Perez, NRCS - District Conservationist<br>Date: 3-16-06, Phone: 512-392-4050 x3 |
| Soil Surface Condition After Harvest (ICNAH) | 3 | Cris Perez, NRCS - District Conservationist<br>Date: 3-16-06, Phone: 512-392-4050 x3 |
| Date of Crop Emergence (EMD, EMM, IYREM) | 01/03/61 | Cris Perez, NRCS - District Conservationist<br>Date: 3-16-06, Phone: 512-392-4050 x3<br>Plants emerge from late February-March. They mature mid June. They go dormant after the first frost, which occurs in November. |
| Date of Crop Maturity (MAD, MAM, IYRMAT) | 15/06/61 | |
| Date of Crop Harvest (HAD, HAM, IYRHAR) | 15/11/61 | |
| Maximum Dry Weight (WFMAX) | 0.0 | Not used in scenario. |
| Maximum Canopy Height (HTMAX) | 122 | Little bluestem (2-4') is a typical range plant for this soil (USDA 2006) in this region (Cris Perez, NRCS). Height data from http://texnat.tamu.edu/cmplants/B-182/main.htm. |
| SCS Curve Number (CN) | 87, 83, 86 | Gleams Manual Table H-4, pasture/range, non-CNT, hydrologic group C, poor condition (USDA, 2000) |
| Manning's N Value (MNGN) | 0.110 | San Antonio Pasture, warm season (I93PWPWN). This file incorporates no tillage and has a cover code (2) representing first year grass, pasture or hay crops. |
| USLE C Factor (USLEC) | 0.004 | San Antonio Pasture, warm season (I93PWPWN). |

| **Table 4. PRZM 3.12 Brackett-Rock Outcrop-Comfort Complex Soil Parameters for Barton Springs - rangeland/pastureland.** | | |
|---|---|---|
| **Parameter** | **Value** | **Source/Comments** |
| Total Soil Depth (CORED) | 43 cm | NRCS Soil Data Mart Database, Hays County, for Brackett-Rock outcrop-Comfort complex, 1 to 8 percent slopes. (http://soildatamart.nrcs.usda.gov/). |
| Number of Horizons (NHORIZ) | 3 | According to an extension agent (Cris Perez), rangelands reside on a variety of soils. Brackett is a common soil type of rangelands in this area. |
| Horizon Thickness (THKNS) | 10 cm (HORIZN =1)<br>5 cm (HORIZN =2)<br>28 cm (HORIZN =3) | Additional data were listed for a 4th HORIZN. However, these were not included in this soil profile since the 4th HORIZN is composed of bedrock. |
| Bulk Density (BD) | 1.4 g/cm3 (HORIZN =1)<br>1.4 g/cm3 (HORIZN =2)<br>1.4 g/cm3 (HORIZN =3) | |
| Initial Water Content (THETO) | 0.28 cm3/cm3 (HORIZN =1)<br>0.28 cm3/cm3 (HORIZN =2)<br>0.251 cm3/cm3 (HORIZN =3) | |
| Compartment Thickness (DPN) | 0.1 cm (HORIZN =1)<br>5 cm (HORIZN =2)<br>4 cm (HORIZN =3) | PRZM Scenario Guidance (2004). |
| Field Capacity (THEFC) | 0.28 cm3/cm3 (HORIZN =1)<br>0.28 cm3/cm3 (HORIZN =2)<br>0.251 cm3/cm3 (HORIZN =3) | |
| Wilting Point (THEWP) | 0.164 cm3/cm3 (HORIZN =1)<br>0.164 cm3/cm3 (HORIZN =2)<br>0.142 cm3/cm3 (HORIZN =3) | |
| Organic Carbon Content (OC) | 1.16 % (HORIZN =1)<br>1.16 % (HORIZN =2)<br>0.73 % (HORIZN =3) | Adjusted using the relationship % OC = % Organic Matter/1.724 (Doucette 2000). |

**Table 5. Soils co-located with natural herbaceous areas of the Barton Spring Segment based on USDA 2006 soils data and USGS 2003 land use data. Bold font indicates a benchmark soil.**

| Soil | Total Acreage | % Area | Drainage Class | KF | Slope (%) | pH | OM (%) | Sand (%) | Silt (%) | Clay (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Brackett | 8,540 | 22.8% | C | 0.37 | 1 - 12 | 8 | 2 | 34 | 38 | 28 |
| Rumple | 5,941 | 15.8% | C | 0.32 | 1 - 8 | 7 | 2 | 34 | 37 | 30 |
| Doss | 4,001 | 10.7% | D | 0.32 | 1 - 5 | 8 | 2 | 7 | 49 | 44 |
| Real | 2,518 | 6.7% | D | 0.28 | 1 - 8 | 8 | 6 | 36 | 34 | 31 |
| Comfort | 1,654 | 4.4% | D | 0.32 | 1 - 8 | 8 | 6 | 28 | 29 | 43 |
| Volente | 1,625 | 4.3% | C | 0.32 | 1 - 8 | 8 | 3 | 7 | 54 | 39 |
| Bolar | 1,591 | 4.2% | C | 0.32 | 1 - 3 | 8 | 2 | 34 | 37 | 30 |
| Sunev | 1,413 | 3.8% | B | 0.32 | 0 - 1 | 8 | 2 | 18 | 52 | 30 |
| Krum | 1,404 | 3.7% | D | 0.32 | 0 - 1 | 8 | 2 | 26 | 29 | 45 |
| Purves | 961 | 2.6% | D | 0.32 | 1 - 5 | 8 | 3 | 23 | 29 | 48 |
| Denton | 907 | 2.4% | D | 0.32 | 1 - 3 | 8 | 3 | 6 | 48 | 46 |
| Austin | 867 | 2.3% | C | 0.32 | 1 - 3 | 8 | 3 | 7 | 48 | 45 |
| Tarpley | 768 | 2.0% | D | 0.32 | 1 - 3 | 7 | 3 | 30 | 30 | 40 |
| Lewisville | 753 | 2.0% | B | 0.32 | 0 - 1 | 8 | 2 | 8 | 51 | 41 |
| Tarrant | 596 | 1.6% | D | 0.32 | 5 - 18 | 8 | 5 | 22 | 28 | 50 |
| Speck | 569 | 1.5% | D | 0.32 | 1 - 3 | 7 | 2 | 34 | 37 | 30 |
| Crawford | 485 | 1.3% | D | 0.32 | 0 - 1 | 7 | 2 | 22 | 28 | 50 |
| Houston Black | 406 | 1.1% | D | 0.32 | 0 - 1 | 8 | 3 | 17 | 28 | 55 |
| Anhalt | 353 | 0.9% | D | 0.32 | 1 - 3 | 7 | 3 | 26 | 29 | 45 |
| Gruene | 341 | 0.9% | D | 0.28 | 1 - 5 | 8 | 2 | 28 | 29 | 43 |
| Heiden | 295 | 0.8% | D | 0.32 | 1 - 3 | 8 | 3 | 22 | 28 | 50 |
| Castephen | 207 | 0.6% | C | 0.32 | 3 - 5 | 8 | 2 | 34 | 32 | 34 |
| Alluvial land | 196 | 0.5% | A | 0.15 | 0 - 1 | 8 | 1 | 90 | 0 | 5 |
| San Saba | 187 | 0.5% | D | 0.32 | 1 - 2 | 8 | 3 | 18 | 29 | 53 |
| Branyon | 160 | 0.4% | D | 0.32 | 0 - 1 | 8 | 3 | 22 | 28 | 50 |
| Seawillow | 141 | 0.4% | B | 0.32 | 1 - 3 | 8 | 1 | 35 | 34 | 31 |
| Tinn | 99 | 0.3% | D | 0.32 | 0 - 1 | 8 | 3 | 22 | 28 | 50 |
| Medlin | 96 | 0.3% | D | 0.32 | 1 - 8 | 8 | 2 | 22 | 28 | 50 |
| Oakalla | 88 | 0.2% | B | 0.32 | 0 - 1 | 8 | 4 | 18 | 48 | 34 |
| Boerne | 73 | 0.2% | B | 0.28 | 1 - 3 | 8 | 1 | 65 | 20 | 16 |
| Orif | 61 | 0.2% | A | 0.28 | 0 - 1 | 8 | 2 | 82 | 9 | 9 |
| Eckrant | 57 | 0.2% | D | 0.32 | 8 - 40 | 8 | 7 | 22 | 28 | 50 |
| Urban land | 50 | 0.1% | D | 0.00 | 0 - 6 | 0 | 0 | 0 | 0 | 0 |
| Altoga | 46 | 0.1% | C | 0.32 | 1 - 3 | 8 | 1 | 7 | 48 | 45 |
| Patrick | 45 | 0.1% | B | 0.32 | 2 - 5 | 8 | 2 | 28 | 29 | 43 |
| Eddy | 15 | 0.0% | C | 0.32 | 1 - 3 | 8 | 1 | 38 | 36 | 26 |
| Hardeman | 2 | 0.0% | B | 0.24 | 3 - 12 | 8 | 1 | 66 | 20 | 14 |
| Travis | 1 | 0.0% | C | 0.24 | 1 - 8 | 7 | 1 | 66 | 19 | 15 |
| Ferris | 0 | 0.0% | D | 0.32 | 8 - 20 | 8 | 1 | 18 | 29 | 53 |
| Gaddy | 0 | 0.0% | A | 0.17 | 0 - 1 | 8 | 0 | 84 | 7 | 10 |

***Sensitive Parameter Uncertainties***

Crop Parameters

As discussed above, rangeland vegetation is a heterogeneous mixture of trees and grasses. For the purposes of modeling, it was necessary to select crop specific parameters (Table 3) that are representative of rangeland plants. In order to model areas that would be more likely to be subject to pesticide applications and susceptible to runoff, grassy areas were selected for the conceptual model of this scenario, rather than tree areas. This decision was necessary for the selection of several sensitive parameters, including CN, USLEC and Manning's *n* values.

For USLEC and Manning's N values, the file for San Antonio Pasture, warm season (I93PWPWN) was selected. This file incorporates no tillage (NT) and has a cover code representing first year grass, pasture or hay crops (2). This file was selected because it models a tillage system and crop that seem appropriate for a rangeland or pastureland. A RUSLE data file also exists for San Antonio range (I93RARAN) but incorporates a cover code (6) which represents no cover (0-7% residue cover on soil surface during critical period) and is commonly used with conventionally tilled crops. This cover code did not seem appropriate to model a pastureland which would have residue during the critical period. Therefore, the file for range was not selected.

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