Quartz Valley Indian Reservation
Water Quality Monitoring Plan

By Kier Associates
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This document is a water quality monitoring plan for the Quartz Valley Indian Reservation (QVIR) and is aimed at gauging trends in attainment of beneficial uses for Reservation waters, in Shackleford Creek and its tributaries Mill Creek and Alder Creek. Beneficial uses as recognized by the U.S. Clean Water Act would include drinking water (MUN), support of cold water fisheries (COLD), fish spawning (SPAWN) and recreational or ceremonial uses (REC). This plan recommends water quality monitoring tools to help determine to what degree different factors limit beneficial uses and to gauge trends over time.

The QVIR lies within the Shackleford Creek watershed, a major tributary of the Scott River, and the Tribe has interest in the health of these aquatic ecosystems because of their role in producing cold water fish. Chinook and coho salmon as well as steelhead trout return to Shackleford Creek to spawn and rely on a healthy Scott River for juvenile rearing and adult migration. Consequently, the QVIR plans to monitor the Scott River to participate as a co-manager of water quality in the main river in order to help restore fisheries that are vital to their culture.

Limiting Factors

Consideration of factors limiting salmon and steelhead production, water quality and attainment of other beneficial uses in Shackleford Creek must be tiered. There are some over-arching factors, such as flow depletion, that can then cause secondary water quality problems as transit time increases and stagnation of water occurs. Limiting factors are most often linked to two current land use activities; logging and agriculture, although mining also occurred in the past. Although the impact of pesticides discharges related to agricultural activity in Shackleford Creek are not documented, pesticides are discussed under limiting factors because of their potential as a human health risk in QVIR drinking water.

Logging and Roads: Upland areas within the Shackleford Creek watershed are extensively logged and have high road densities (see Appendix A). Compaction of soils and changes in routing of storm water on logged areas and logging roads are known to:

- Increase peak discharge and decreased base flows (Montgomery and Buffington, 1993; Jones and Grant, 1996),
- Increase sediment yield (Hagans et al., 1986, de la Fuente and Elder, 1998), and
- Decrease large wood available for recruitment to streams (Reeves et al., 1993; Schuett-Hames et al., 1999).

The potential changes in aquatic conditions related to upland disturbance are described below, while the description of conditions in Shackleford Creek uplands based on GIS and other data can be found in Appendix A.

Increased Peak Flows: Elevated peak discharge can increase median particle size distribution to those greater than optimal for salmonid use, wash out large wood, and trigger bank failures and channel scour. Channel changes can include decreased pool frequency and depth (Buffington and Montgomery, 1993). Wider and shallower channels also are more subject to warming. Although less well studied, hydrologic changes associated with compaction of a watershed can also lead to decreased summer base flows.

Increased Sediment Yield: Sediment yield is a noted problem in the Scott River watershed (NCRWQCB, 2003; 2005). Fine sediment comes primarily from surface or gully erosion and Sommarstrom et al. (1990) identified road cuts and road fills on decomposed granitic soils as a major source of fines in the Scott River watershed.

Fine Sediment: High levels of sand and fine sediment can fill interstitial spaces in stream gravels, decrease salmonid egg and alevin survival and reduce aquatic insect habitat. Decreased aquatic invertebrate production can diminish food resources for juvenile salmonids. Smaller sediment particles are highly mobile and may cause diminished pool frequency and depth, thus reducing salmonid juvenile carrying capacity and adult salmonid holding habitat.

Mass Wasting: The coarse and fine sediment yielded by mass wasting can cause channel aggradation, loss of pool habitat, changes in median particle size, decreased spawning gravel quality and channel adjustments that facilitate stream warming.

Large Wood Depletion: Changes in riparian conditions can increase ambient air temperature over streams and reduce relative humidity, thus leading to stream warming (Bartholow, 1989; Pool and Berman, 2001). Cold air moving down slope from Marble Mountain peaks in winter may also cause elevated risk for the formation of anchor ice along streams where canopy is lacking. Pools formed by large wood are extremely important as nursery areas for coho salmon juveniles (Reeves et al., 1988) that must spend one year in freshwater before migrating to the ocean. Large wood depletion can, therefore, cause diminished aquatic habitat complexity, reduced pool frequency and lower carrying capacity for juvenile coho. Large coniferous trees in riparian zones may take decades or centuries to grow to sufficient size to be useful in buffering air temperatures and providing wood of sufficient size to provide lasting habitat value (Shuett-Hames et al., 1999).

Agricultural Water Diversion: Flow depletion in Shackleford Creek due to water extraction for farming and ranching causes warming as water volume is reduced and loss of surface flow (Figure 1). Decreasing flows may cause riffles to become shallow or the formation of isolated pools. Growth of periphyton covering stream substrate will increase with warming water temperatures and would also be increased by nutrient rich agricultural return water. High rates of photosynthesis by algae in low flow conditions can cause large nocturnal and diurnal fluctuations in pH and dissolved oxygen. The secondary effects related to high photosynthetic activity in stagnant, de-watered reaches are not targeted because loss of flow is an over-riding impact.

Figure 1. Photo showing the delta of Shackelford Creek in August 1997 with the stream running dry.

Pesticides: Many of the leading pesticides used in Scott Valley and the Shackleford/Mill Creek drainage are herbicides that have no recognized levels of exposure for human health risk set by the U.S. Environmental Protection Agency or the State of California (EDW, 2005). None the less, most of these substances are likely to cause human health problems at some level of exposure and many are recognized as potential carcinogens. Table 1 show the top pesticides used in the Shackleford/Mill and Scott River basins, respectively.

Table 1. Top ten pesticides used in the Shackleford-Mill Creek watershed and the Scott River watershed from 1990 to 2004. Data from the California Pesticide Use Reporting Database.

Use Rank	**Shackleford/Mill**	**Scott River**
1	Paraquat Dichloride	Paraquat Dichloride
2	Trifluralin	Hexazinone
3	Hexazinone	Diuron
4	Metribuzin	Glycophosphate
5	Glycophosphate	2,4-D Dimethylamine Salt
6	2,4-D Dimethylamine Salt	Metribuzin
7	2.4-D Butoxyethanol Ester	2.4-D Butoxyethanol Ester
8	Norflurazon	Trifluralin
9	MCPA, Dimethylamine Salt	2,4-D, Isooctyl Ester
10	Atrazine	Chloropyrifos

Monitoring Locations, Methods and Timing of Samples

Monitoring methods are recommended below that can best determine whether beneficial uses of water are being attained on the QVIC Reservation and in the Shackleford Creek watershed and what trends for parameters limiting attainment of beneficial uses over time.

The QVIR monitoring locations (Table 2 & Figure 2) are arrayed so as to allow a holistic assessment of Shackleford Creek and to collect mainstem Scott River data to facilitate participation in co-management of cold water fisheries resources. Upper Shackleford Creek locations start within the U.S. Forest Service designated Wilderness areas below the outlet of Campbell Lake (SC), below the convergence of Summit Creek (SBS), and at the Wilderness trailhead (ST). Middle and lower Shackleford Creek locations are at the USFS road crossing (SR), at the top of the QVIR ownership (SQVIR) and on a private parcel owned by a tribal member just below the convergence with Mill Creek (ST).

Mill Creek monitoring locations start on USFS lands just below Mill Creek Ponds (MU), continue downstream to a site within BLM ownership (MM) and include a reach at the Quartz Valley Elementary School. Alder Creek (AL) and the mainstem Scott River (SM) also have one monitoring station each.

Table 2. Locations for QVIR water quality monitoring with station identification codes.

Monitoring Location	ID Number
Upper Shackleford below Campbell Lake Outlet	SC
Upper Shackelford below convergence with Summit Creek	SBS
Upper Shackleford at Wilderness trailhead	ST
Shackleford at USFS road crossing	SR
Shackleford on QVIR	SQVIR
Shackleford at Charlie Tom's Property	SCT
Upper Mill below Mill Creek Ponds (USFS)	MU
Middle Mill Creek on BLM	MM
Lower Mill Creek at Quartz Valley Elementary School	ML
Alder Creek	AL
Mainstem Scott River below the convergence with Shackleford	SM

Pool Frequency and Residual Depth: Measuring the frequency of pools and residual pool depth is a cost-effective and repeatable technique for trend monitoring. Methods should follow those of the Aquatic and Riparian Effectiveness Monitoring Program (AREMP) protocols (Gallo, 2002). Pool occurrence is an index of channel form, with expected frequencies described by Montgomery and Buffington (1993) for control watersheds. Pool depth is an indicator of suitability for salmonid juveniles as well (Chen, 1992). This method is less accurate, but also less expensive, than taking longitudinal profiles that measure the depth contours of the thalweg in an entire reach.

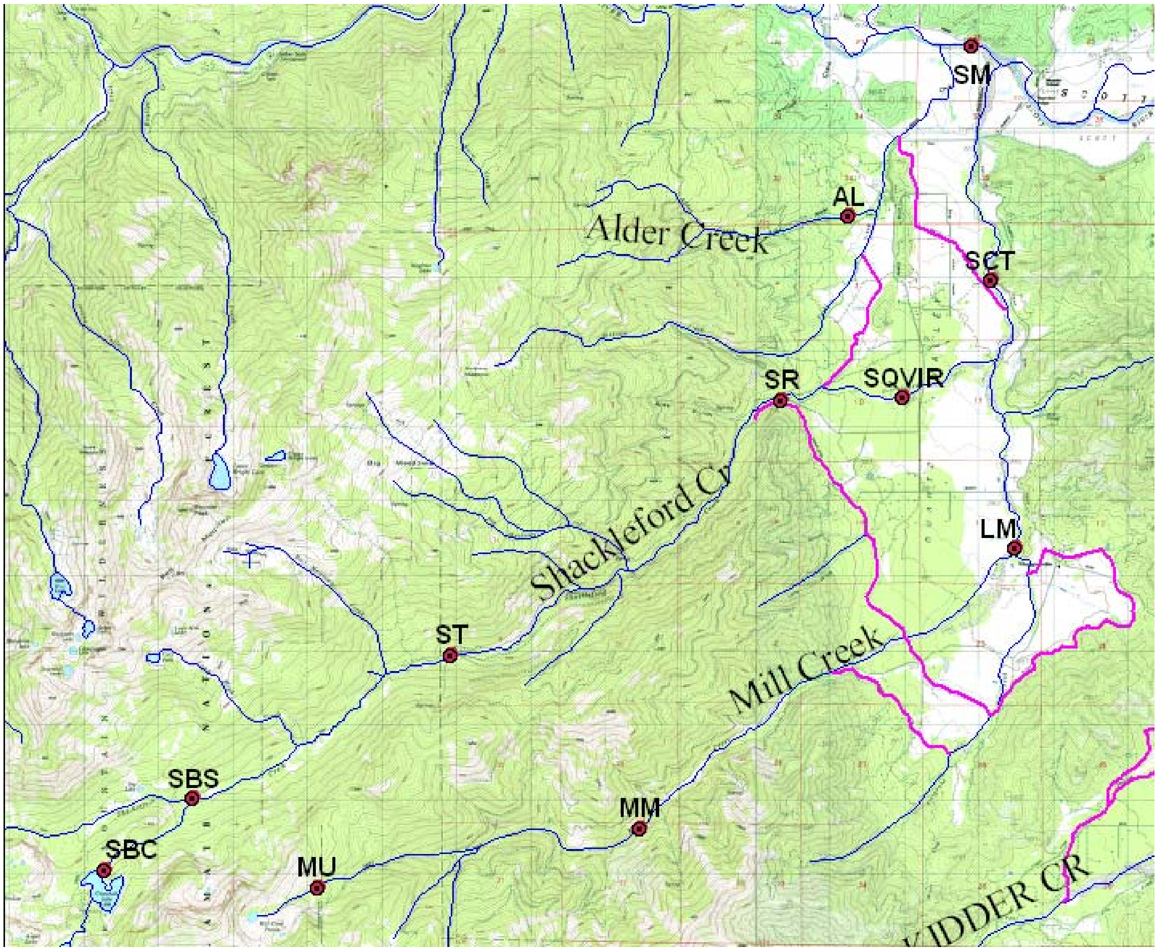

Figure 2. Location of QVIR water quality monitoring stations.

Location and Timing: Measurement of pool frequency and residual depth should be conducted in the reach of Shackleford Creek on the QVIC Reservation and in a reach of Mill Creek where access permits. Measurements should be taken annually unless flows were so low due to drought conditions that bedload movement did not likely take place.

Volume of Sediment in Pools (V*): The ratio of the volume of sediment in pool habitats to the combined total of water and sediment is known as V-star (V*), which can be used as an index of sediment supply (Hilton and Lisle, 1992).

Location and Timing: If there is access to reaches on Mill Creek that contain ten or more pools, use of V* should be considered to gauge sediment flux. Ten pools are required for a statistically valid sample size. Monitoring should take place annually unless drought conditions make it likely that no bedload movement occurred. If annual samples prove infeasible, monitoring after high flow years when bedload movement is active should be a priority.

Median Particle Size (D50): The median size of stream substrate at pool tail crests where salmonids might spawn is an indicator of watershed health and cumulative watershed effects on channel processes (Gallo, 2002; Knopp, 1993). Knopp (1993) noted that streams with intensive logging and high road densities in northwestern California streams had D50 values of less than 37 mm. The U.S. Forest Service rating curve for D50 in their Ecosystem Management Decision Support model (Reynolds, 2001) indicates the functional range for salmonid spawning is 45 mm to 128 mm. Larger D50 can be indicative of increased shear stress on stream beds related to increased peak discharge (Montgomery and Buffington, 1993).

Location and Timing: Median Particle size should be measured across stream profiles in pool tail crests of the upper reach at the Marble Mt. Wilderness trailhead, the road crossing down from the trailhead, at several transects on QVIC ownership and at least three locations in Mill Creek.

Large Wood: Large woody debris (LWD) is important in helping shape stream habitats and forces the scour of pools, which serve as ideal rearing habitat for salmonid juveniles. There is evidence that riparian logging has taken place in Shackleford and Mill Creeks resulting in diminished large wood recruitment potential (Schuett-Hames et al., 1999). Low LWD supply can also serve as an indicator of increased peak flows, which scour riparian zones and transport large wood downstream. LWD supply in Shackleford and Mill Creeks may be a factor limiting habitat diversity and salmonid carrying capacity, but lack of LWD in valley reaches might be as a result of removal by farmers and ranchers.

Location and Timing: LWD surveys would likely be most telling in reaches of Shackleford and Mill Creek above agricultural activities to avoid problems with large wood removal confounding monitoring results. LWD studies in Shackleford Creek should likely be deferred until access to the reach between the Wilderness trailhead and the USFS road crossing can be obtained. When access is available, LWD availability should be contrasted between headwater reaches near stations SC, SBS and ST with middle reaches below industrial timberlands but above site SR. If LWD monitoring is carried out in the future, the methods of Shuett-Hames et al. (1999) or Gallo (2002) should be employed.

Temperature: All Pacific salmon require cold water (McCullough, 1999), which makes water temperature a good surrogate for whether habitat is suitable for these cold water species. Automated temperature probes allow acquisition of voluminous amounts of data for a low cost. Probes placed throughout Shackleford Creek will show seasonal patterns associated with warming related to flow depletion.

Location and Timing: Table 2 describes the location of placement of automated temperature probes and the recommended timing for placement. Dates for probe deployment may vary with water year. For example, during high flow years deployment of probes may need to be after April 15, particularly in larger stream reaches. If fall rains do not arrive early, leaving probes in place to measure suitability for chinook salmon spawning in some reaches through October 31 may be desirable.

Flow: The level of flow in Shackleford Creek has direct bearing on whether the stream maintains cold water temperatures as well as other beneficial uses. QVIR intends to use

Table 2. Location of automated temperature probes and recommended duration of data collection.

Location	Timing
Shackleford below Campbell Lake (SC)	April 15 to October 1
Shackleford below Summit Creek (SBS)	April 15 to October 1
Shackleford at Trailhead (ST)	April 15 – October 1
Shackleford at USFS Road (SR)	April 15 – October 1
Shackleford at top of QVIR (SQVIR_1)	April 15 – October 1 (or when dry)
Shackleford at bottom of QVIR (SQVIR_2)	April 15 – October 1 (or when dry)
Shackleford below Mill Creek (SCT)	April 15 – October 1
Upper Mill Creek on USFS (MU)	April 15 – October 1
Middle Mill Creek on BLM (MM_1)	April 15 – October 1
Middle Mill Creek at lower BLM (MM_2)	April 15 – October 1
Lower Mill Creek at QV Elementary (ML)	April 15 – October 1
Alder Creek (AL)	April 15 – October 1

flow data collected in the middle reaches of Shackleford Creek by the California Data Exchange Center in cooperation with the Siskiyou Resource Conservation District. Flow measurements will help confirm patterns of warming related to flow depletion as recognized by Watershed Sciences (2003). Photo points should be established at all stations so that the appearance of the stream is recorded at different flows.

Location and Timing: Spot flow measurements should be taken using a hand held pygmy current meter at all monitoring locations. Weekly flow measurements might suffice in spring, but increased frequency of measurements would be desirable for detailed patterns as Shackleford Creek starts to go dry. In other words, sampling should be intensive when agricultural diversion increases rapidly.

Aquatic Macroinvertebrates: Insect species that thrive in streams can be used as water quality indicators (Barbour et al., 1999). QVIR monitoring should follow protocols described by (CDFG, 1999) and employed by Friedrichsen (1998). Friedrichsen (1998) studied aquatic invertebrates of the Eel River basin from 22 locations as part of a water quality reconnaissance that also included widespread deployment of automated temperature sensors. Parameters of interest in determining the health of streams were the EPT index (total mayflies, stoneflies and caddisfly species), Richness (total species present) and the Percent Dominance Index (percent of sample of most abundant species).

Location and Timing: Aquatic invertebrates should be collected at all Shackleford, Mill and Alder Creek monitoring locations using a kick net with three samples taken across the channel profile following the protocols as described by CDFG (1999). Samples should be collected in Spring and Fall, on the same day if possible. The timing of spring time sampling may vary depending on flow, but would likely be set for when mainstem locations such at the USFS road crossing (SC) are low enough to allow. Obviously no sampling can take place if the stream channel is dry in Fall.

Pesticides: Current information related to pesticide use in the Shackleford Creek watershed are not sufficiently detailed to understand whether they may be a problem for QVIR drinking water or a limiting factor for salmonids (see Appendix A). Hexazinone and Atrizine are used in the watershed and are known to be very water soluble and also to have a long half life. These chemicals would be good candidates for monitoring in QVIR ground water wells, however, the spatial data suggest that there is very little use of these chemicals above QVIR. QVIR staff should obtain more detailed data from the Siskiyou County Agricultural Commissioner to enable a more detailed analysis of the location and amount of use of these chemicals relative to the location of wells used by the Tribe. Although catching pesticide residue in surface water runoff has a low likelihood of detection, differences in aquatic macroinvertebrate community structure at various locations may be helpful in understanding potential pesticide problems.

Scott River Multi-Channel Recorder: The QVIR wishes to establish a continuous recording water quality monitoring station downstream of the mouth of Shackleford Creek in the mainstem Scott River. This station would employ a Yellow Springs Instrument (YSI) or Hydro Lab data probe to capture temperature, conductivity, pH and turbidity data. After a year or two of Scott River data collection below Shackleford Creek, the QVIR plan to place a second multi-channel recorder in the upper Scott River 6 miles below the convergence of the East Fork and South Fork. These stations would provide a useful comparison of water quality above and below major agricultural activities and allow participation of the QVIC as co-managers in TMDL Implementation.

Location and Timing: The critical monitoring period for temperature, conductivity and pH would be during summer while turbidity information would be more useful if collected during peak flow events in winter. The multi-channel recorders should be deployed year around, if the devices can be prevented from being dislodged or destroyed by high flows.

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QVIR Monitoring Plan Appendix A:
Shackleford Creek Limiting Factors Background Information

This Appendix provides Shackleford Creek specific information on upland conditions based on GIS data and likely relationships of disturbance and resultant aquatic conditions based on local and regional scientific literature.

Increased Peak Flows: The rain-on-snow or transient snow zone is where logging and road building create the highest risk for elevating peak flows (Jones and Grant, 1996). This area of greater risk generally ranges between 3,500-5,000 feet in northern California (Armentrout et al., 1999). The rain-on-snow zone in the Shackleford Creek watershed almost directly overlaps with the private timber lands that have been actively managed and have high road densities (Figure 2). De la Fuente and Elder (1998) described effects of a rain-on-snow event as a result of the January 1, 1997 storm on U.S. Forest Service lands. Road failures tended to occur at the upper limit of the rain-on-snow zone, where debris torrents were initiated and often triggered channel scour for long reaches downstream.

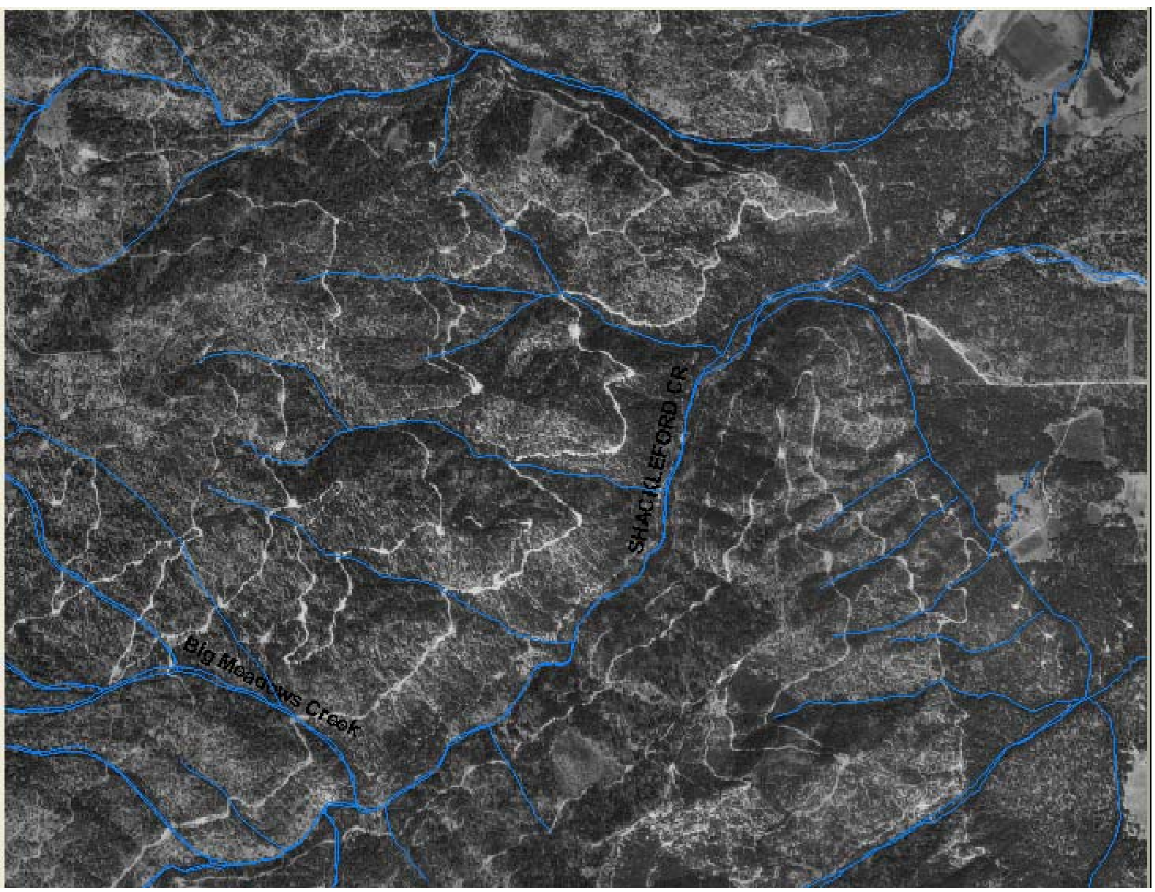

Figure 1. U.S. Geologic Survey orthophoto showing extensive logging and network of logging roads on private lands within the Shackleford Creek watershed.

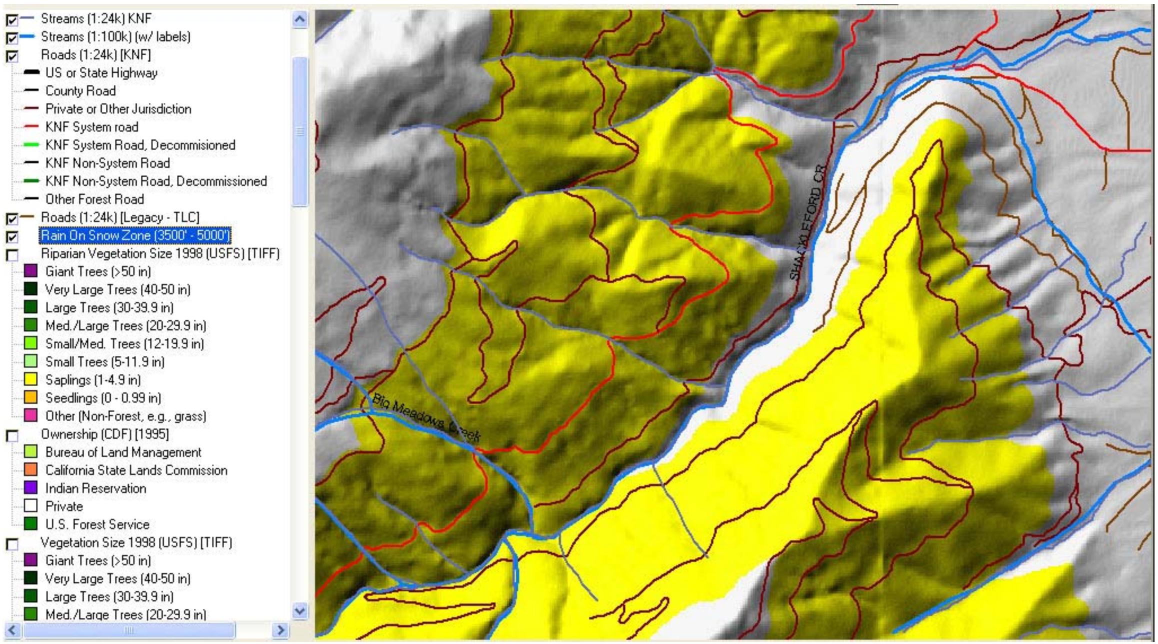

Figure 2. The rain-on-snow or transient snow zone (3500 and 5000 feet in elevation) is shown here in yellow. High rates of logging with dense road networks may alter runoff.

Fine Sediment: Disturbance of land with unstable soil types may yield increased fine sediment delivery to streams. Sommarstrom et al. (1990) found high fine sediment yield in watersheds on the west side of the Scott River Valley, but that the Schackleford Creek drainage had only 7% granitic terrain, the most erodible Scott River soil type. Mill Creek, however, has a substantial area of decomposed diorite (Figure 3), which has similar tendency for surface and gully erosion to decomposed granite (Armentrout et al., 1999). Consequently Mill Creek should be monitored for fine sediment while doing so in the mainstem Shackleford Creek is unnecessary.

Mass Wasting: Mass wasting events were greatly elevated in the lower west side of the Scott River watershed where logging or road building took place on steep, unstable slopes prior to the January 1997 storm (de la Fuente and Elder, 1998). Klamath National Forest studies showed that 437 miles of stream channel occurred as a result of the January 1, 1997 storm event. Channel adjustments took place in part because of debris slides on managed lands and failures of multiple stream crossing on the same stream. Armentrout et al. (1999) recommend having fewer than 1.5 crossings per stream mile in order to decrease risk of multiple stream crossing failures that cause catastrophic cumulative watershed effects damage to stream channels. Streams and roads are under-represented in Figure 2, yet one can see that there are many more crossings than 1.5 per mile.

Channel widening and shallowing in response to debris torrents on January 1997 increased water temperatures on some Klamath National Forest streams (de la Fuente and Elder, 1998) and in severe cases caused loss of surface flows. Only limited channel scour was noted by de la Fuente and Elder (1998) in Shackleford Creek, but their study focused

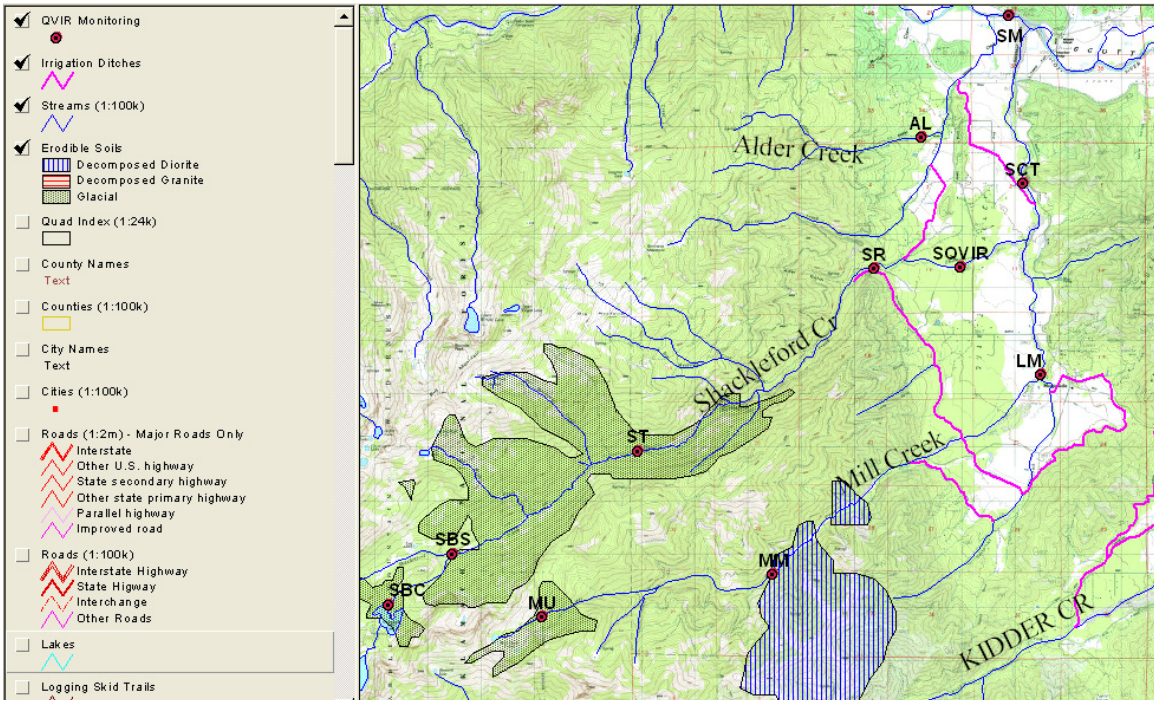

Figure 3. This map shows erodible soil types in the Shackleford and Mill Creek watersheds according to data provided by Sommarstrom et al. (1990).

on USFS lands; consequently, not all channel adjustments on reaches of streams flowing through private lands would have been mapped. Landslides yield both coarse and fine sediment and de la Fuente and Elder (1998) found that roads triggered the most landslides on Klamath National Forest followed by those areas that were recently burned or logged (Figure 4).

Large Wood Depletion: Logging in riparian zones can also cause a decrease in availability of large wood that may be contributed to stream channels (Schuett-Hames et al., 1999). Landsat derived vegetation data accurate to the one-hectare scale is available for the Scott River basin and Shackleford Creek from the U.S. Forest Service (Warbington et al., 1999). Landsat data from 1996 shows very small average tree diameter in along Shackleford Creek and its tributaries indicating early seral conditions and active recent logging in stream side areas (Figure 5).

Landsat data can also be used to track changes in vegetation by comparing data from various years (Lavien et al., 2001). Figure 6 and 7 show "change scene detection" data using 1994 and 1999 images on Shackleford Creek and Mill Creek, respectively. Both images show a decrease in canopy cover in near stream areas, which can indicate either logging or removal of riparian cover due to channel scour. Forest re-growth and recovery from past disturbance is shown in blue and light blue, and in some cases indicates advancing ecological succession as riparian zones recover from past logging. The aerial photo on Mill Creek also shows a distinct delta or alluvial fan as the stream comes out of the upper canyon, which indicates a history of sediment evulsions.

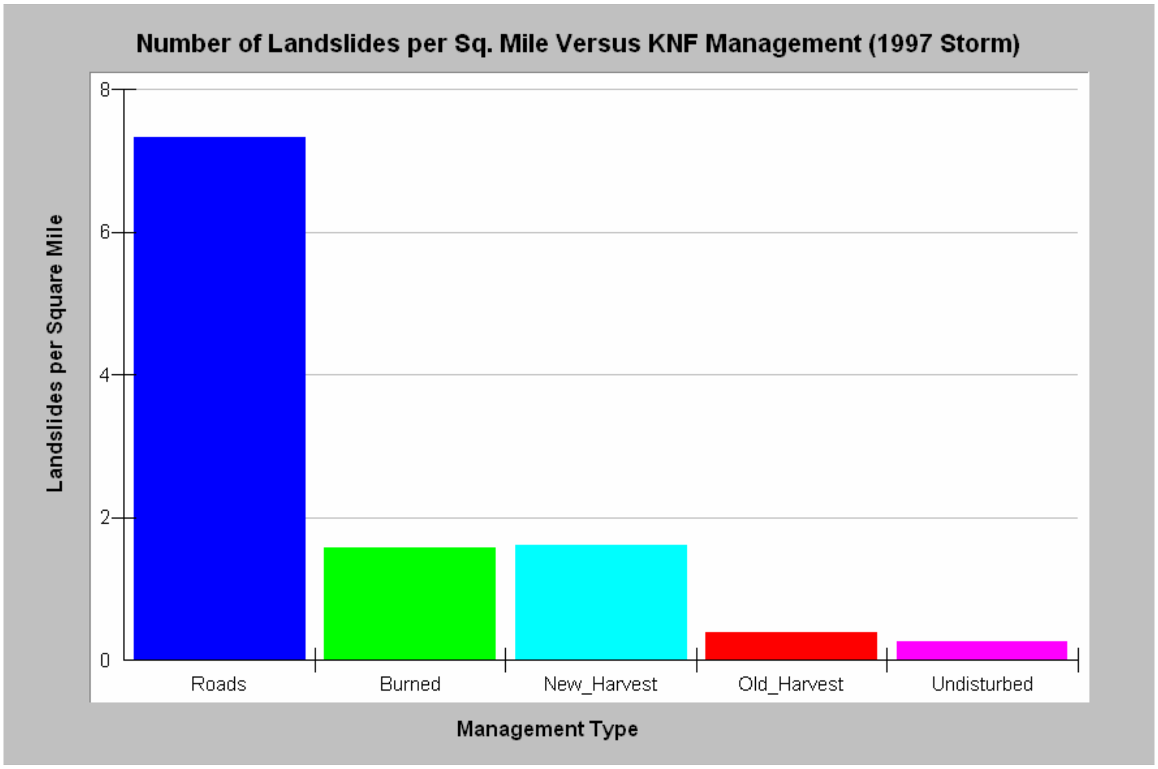

Figure 4. Studies by Klamath National Forest found the associations summarized in this chart between land use history and landslides. Data from de la Fuente and Elder (1998).

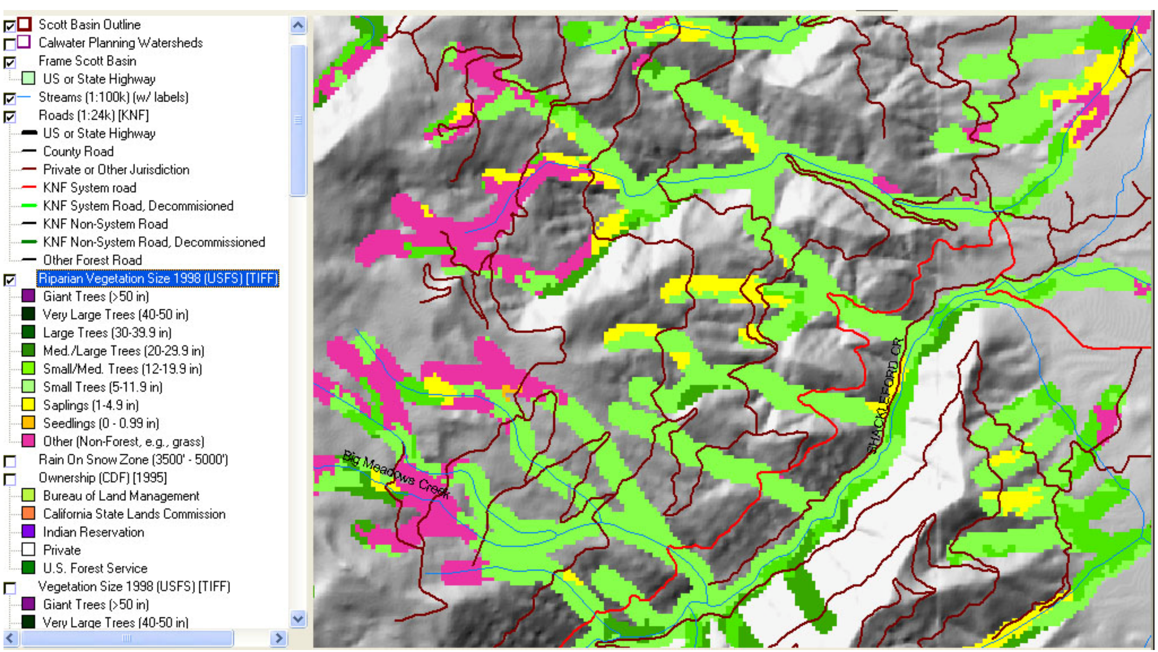

Figure 5. Riparian vegetation and tree size are shown above based on Landsat imagery as classified by the U.S. Forest Service Spatial Analysis Lab in Sacramento. Small tree diameters indicate recent logging.

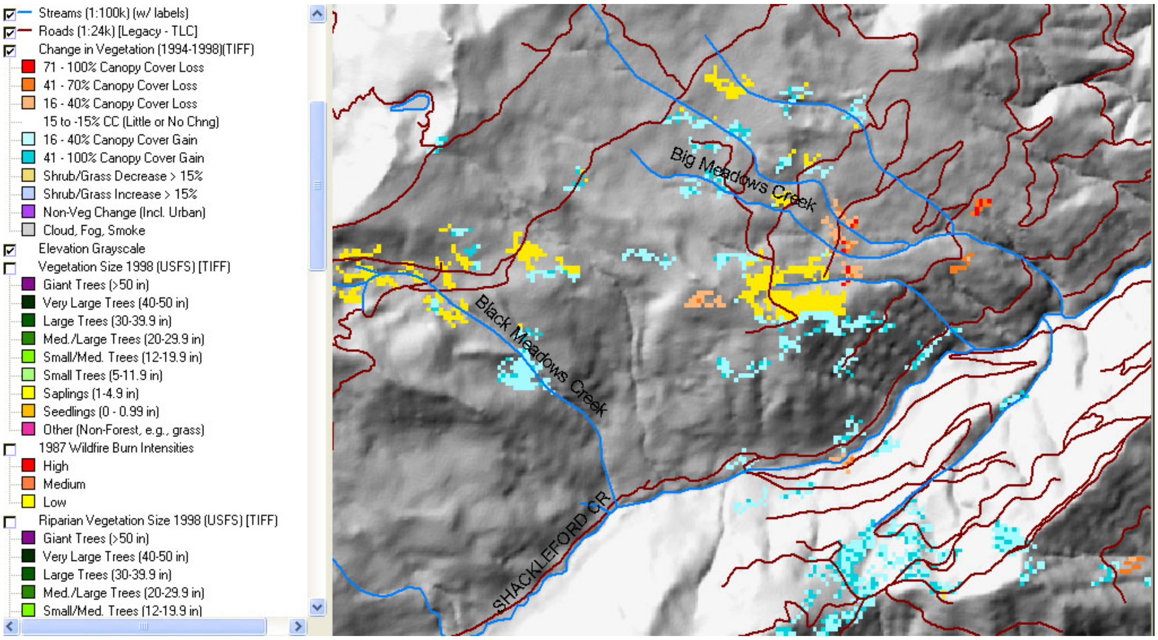

Figure 6. This map image shows streams, roads and changes in vegetation between 1994 and 1998 according to the U.S. Forest Service Spatial Analysis Lab. Vegetation changes in near stream riparian zones include decreases likely related to logging (yellow, orange red) and increases (blues) where stream side trees are growing back from previous logging. Data from the USFS Spatial Analysis Lab, Sacramento, CA.

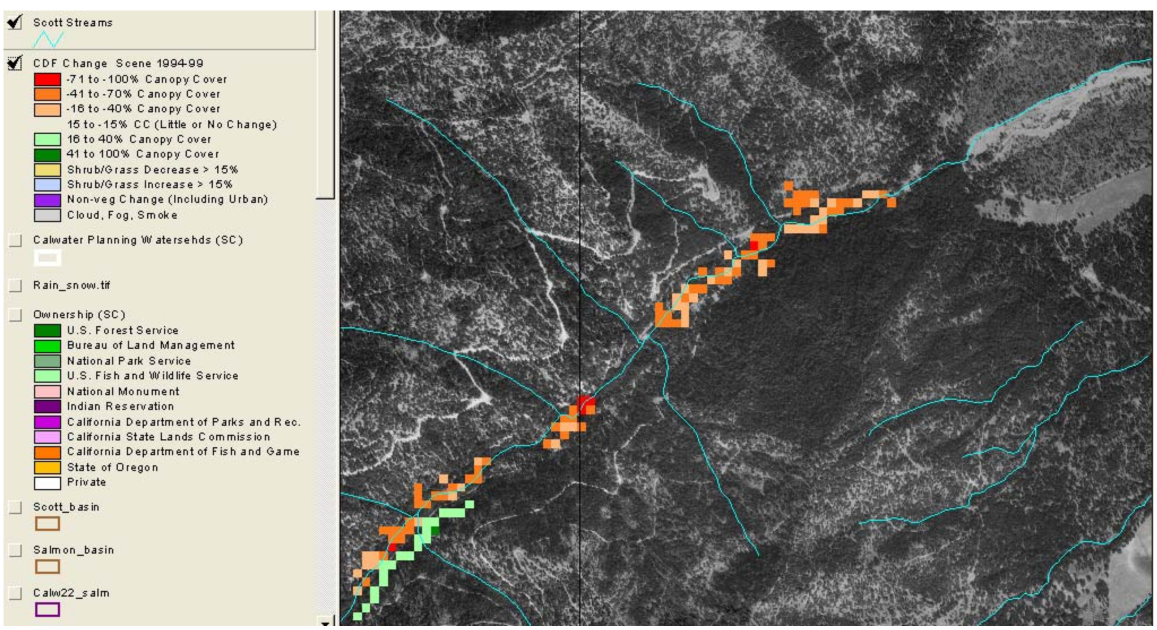

Figure 7. This map image shows change scene detection for a reach of Mill Creek based on 1994 and 1999 Landsat images. Note also the wide gravel bar where Mill Creek exits the canyon at upper right in the image. Data from the USFS Spatial Analysis Lab, Sacramento, CA.

Agricultural Water Diversion Impacts: Obviously loss of surface flow in Shackleford Creek causes an almost total loss of carrying capacity for salmonids. The National Academy of Sciences (2003) also makes a clear case that flow depletion is at the root of temperature problems in the Scott River, and the same holds true for its tributary Shackleford Creek. As flows drop, transit time for water increases allowing an opportunity for stream warming. Lower level thermal infrared video imagery of Shackleford Creek (Figure 8) illustrates how flow depletion causes water temperatures to increase and ultimately causes the stream to go dry (Watershed Sciences Ltd., 2003). Shackleford Creek is cold enough for coho salmon in its upper reaches, but rapidly warms as flows are depleted. Mill Creek contributes to surface flows in the lower reach, but Shackleford dries up again due to diversion near the mouth.

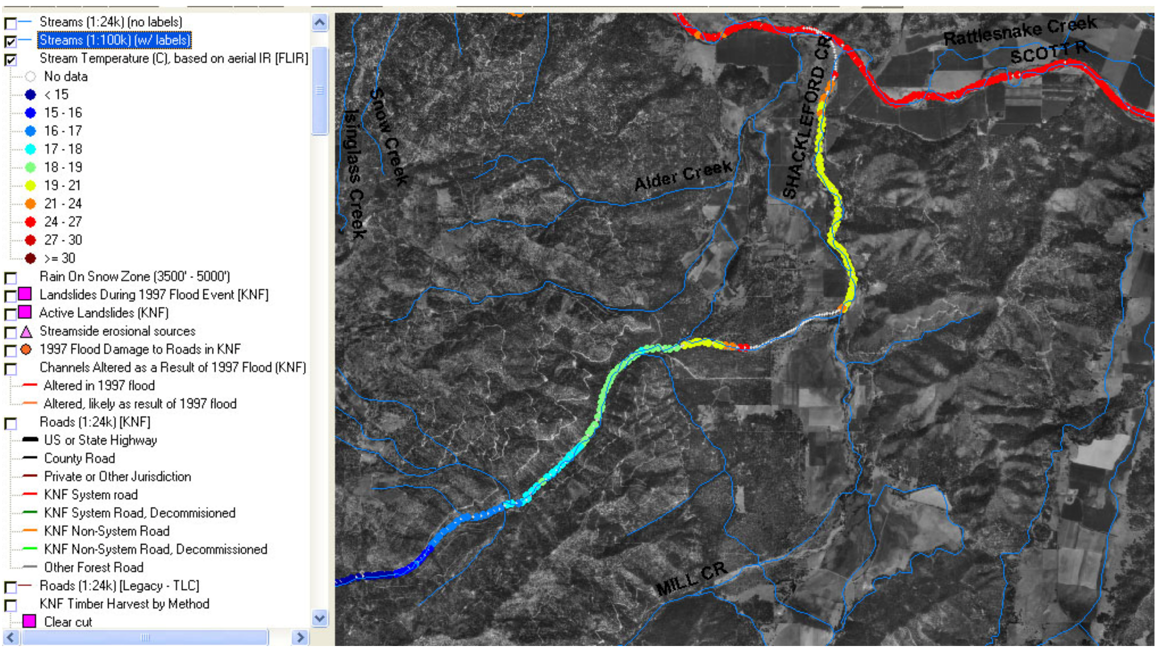

Figure 8. Thermal infrared radar imagery of Shackleford Creek as captured by Watershed Sciences (2003).

Pesticides: Data on use of pesticides comes from the California Pesticide Use Reporting Database (http://www.cdpr.ca.gov/docs/pur/purmain.htm) that contains data on agricultural and industrial applications of registered pesticides (including herbicides, insecticides, etc). The database may not be complete because reporting may not be complete. Figures 9 and 10 show the registered use of pesticides in Shackelford Creek and the Scott Valley, respectively. The resolution of data is one square mile and some data for the Shackleford and Mill Creek basins overlap with adjacent sub-basins. Polygons were included in the maps, if the square mile section was 1/10 inside the watershed of interest. Due to the limits of the geographic extent of the database, it is best used to look at the relative quantities of the different pesticides that are applied in the watershed and on which crops they are being applied, rather than to look at the absolute amounts used. The Siskiyou County Agricultural Commissioner may maintain parcel-level GIS layers that could greatly enhance geographic accuracy and provide more useful information for decision making.

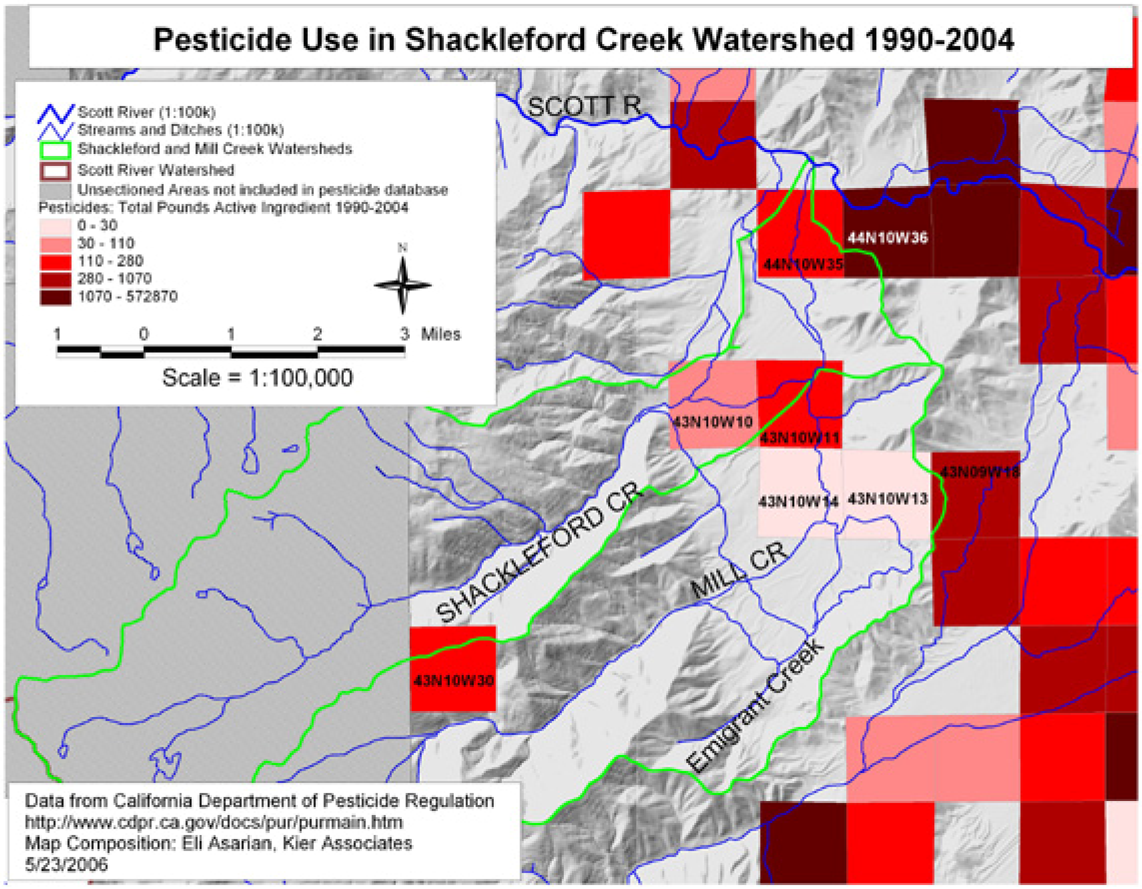

Figure 9. This map shows pesticide use in the Shackleford Creek basin, including Mill Creek with colors representing cumulative total amount of pesticides used between 1990 and 2004. Data from the California Pesticide Use Reporting Database.

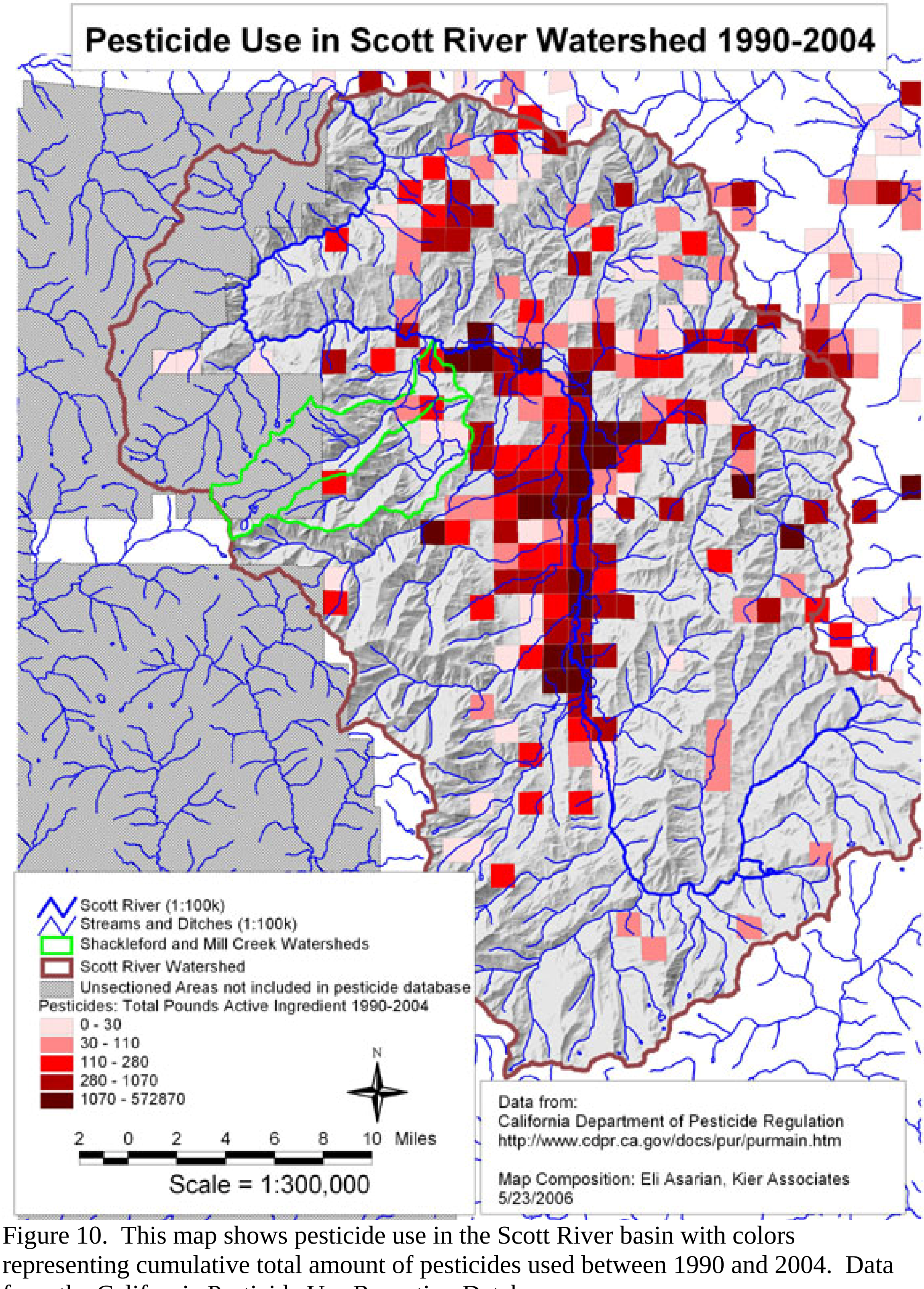

Figure 10. This map shows pesticide use in the Scott River basin with colors representing cumulative total amount of pesticides used between 1990 and 2004. Data from the California Pesticide Use Reporting Database.

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