

detected in adjacent ponds and linked to die-offs and deformities in California tiger salamanders and spadefoot toads, and die-offs of invertebrates that form most of both species' prey base (S. Sweet, *in litt.*, 1993). Lefcort *et al.* (1997) found that oil had limited direct effects on 5-week-old marbled (*Ambystoma opacum*) and tiger salamanders (*A. t. tigrinum*). However, salamanders from oil-contaminated natural ponds metamorphosed earlier at smaller sizes, and those from oil-contaminated artificial ponds had slower growth rates, than larvae raised in non-contaminated ponds. Their studies did not address effects on eggs and early larval stages, where the effects may be more pronounced.

Hatch and Burton (1998) and Monson *et al.* (1999) investigated the effects of one component of petroleum products and urban runoff (fluoranthene, a polycyclic aromatic hydrocarbon) on spotted salamanders (*A. maculatum*), northern leopard frogs (*Rana pipiens*), and African clawed frogs (*Xenopus laevis*). In laboratory and outdoor experiments, using levels of the contaminant comparable to those found in service stations and other urban runoff, the researchers found reduced survival and growth abnormalities in all species. The effects were worse when the larvae were exposed to the contaminant under natural levels of sunlight, rather than in the laboratory under artificial light.

In Sonoma County, there are a number of records of California tiger salamanders using roadside ditches. Many are in areas where there are no known breeding ponds, and these animals are utilizing the only marginal habitat remaining. Also, many pools in these areas have likely been destroyed, leaving these marginal sites as the only option for breeding. In light of this increased urbanization occurring in Sonoma County, along with concurrent increases in traffic, the risk factor associated with contaminants in runoff likely will increase in both roadside ditches and across the general landscape.

#### Agricultural and Landscaping Contaminants

In Sonoma County, over 1.4 million kilograms (3.1 million pounds) of agricultural chemicals were used in 2000 on grapes, apples, rights of way, structural pest control, and landscape maintenance (California Department of Pesticide Regulation 2000, Internet Website). Chemical use occurring on or near tiger salamander breeding sites in Sonoma County is primarily associated with rights of way, structural pest

control, and landscape maintenance. These chemicals included metam-sodium, methyl bromide, mancozeb, petroleum oil, phosmet, chlorpyrifos, pendimethalin, parathion, paraquat dichloride, fosetyl-aluminum, acephate, cryolite, and malathion, some of which are extremely toxic to aquatic organisms, such as amphibians and the organisms on which they prey.

Even if toxic or detectable amounts of pesticides are not found in breeding ponds or groundwater, salamanders may still be affected, particularly when chemicals are applied during the migration and dispersal seasons. All but one of the remaining eight documented salamander breeding sites in Sonoma County may be directly or indirectly affected by toxic landscaping chemicals due to the presence of housing developments within their drainage basins. Sparling *et al.* (2001) examined pesticide usage and amphibian (*Rana* and *Bufo* spp.) population declines in California and found that pesticides have been instrumental in declines of these species. Davidson *et al.* (2001, 2002) also found a strong relationship between the declines in four California native ranid species and upwind agriculture, specifically the use of agrochemicals upwind of ranid populations that are not directly impacted by habitat destruction. However, Davidson *et al.* (2002) were unable to find a significant overall relationship between upwind agriculture and the California tiger salamander's decline.

#### Rodent Control

California tiger salamanders spend much of their lives estivating in underground retreats, typically in the burrows of ground squirrels and gophers (Loredo *et al.* 1996; Trenham 1998a). Dave Cook (pers. comm., 2001) found that pocket gopher burrows are most often used by California tiger salamanders in Sonoma County. Both of these species are classified as non-game mammals by CDFG, which means that if pocket gophers or ground squirrels are found to be injuring growing crops or other property, including garden and landscape plants, they may be controlled at any time and in any legal manner by the owner or the tenant of the premises (University of California Integrated Pest Management (UCIPM) internet website 2002).

Legal methods of pocket gopher control include trapping, strychnine-treated grain bait, and anticoagulant baits. Poisoned grains (anticoagulant baits) are the most common method used to control ground squirrels around homes and other areas where children,

pets, and poultry are present (UCIPM internet website 2002; Jon Shelgrin, California Department of Pesticide Regulation, pers. comm., 2002). Zinc phosphide is highly toxic to freshwater fish and to non-target mammals (Extension Toxicology Network (EXOTONET) 1996). Zinc phosphide, a rodenticide and restricted material, turns into phosgene gas, which is toxic to the rodents once ingested. There is little risk of California tiger salamanders ingesting any of these baits; however, the use of these grains may impact the California tiger salamanders indirectly if washed into burrows or ponds used by the species.

Two of the most commonly used rodenticides, chlorophacinone and diphacinone, are anticoagulants that cause animals to bleed to death. These chemicals can be absorbed through the skin and are considered toxic to fish and wildlife (U. S. Environmental Protection Agency 1985; EXOTONET 1996). These two chemicals, along with strychnine, are used in Sonoma County to control rodents (R. Thompson, Science Applications International Corporation, *in litt.*, 1998). Although the effects of these poisons on California tiger salamander have not been assessed, any uses in close proximity to occupied California tiger salamander habitat could have various direct and indirect toxic effects. Gases, including aluminum phosphide, carbon monoxide, and methyl bromide, are used in rodent fumigation operations and are introduced into burrows by either using cartridges or by pumping. When such fumigants are used, animals inhabiting the fumigated burrow are killed (Salmon and Schmidt 1984).

In addition to possible direct effects of rodent control chemicals, control programs probably have an adverse indirect effect on California tiger salamander populations. Control of ground-burrowing rodents could significantly reduce the number of burrows available for use by the Sonoma County California tiger salamander (Loredo-Prendeville *et al.* 1994). All but one of the remaining Sonoma County California tiger salamander breeding locations exist in areas that are likely to experience a heightened degree of rodent control due to landscaping concerns surrounding residential developments. Because the burrow density required to support Sonoma County California tiger salamanders in an area is not known, the loss of burrows as a result of control programs cannot be quantified at this time. However, Shaffer *et al.* (1993) stated that rodent control programs may be responsible for the lack of California