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FOOD SAFETY AND RODENT CONTROL IN LEAFY GREEN CROPS

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Abstract: In 2006 spinach contaminated with *Escherichia coli* resulted in the death of 3 people and over 200 illnesses. The contaminated spinach was traced to a field in California. In 2007 produce industry representatives developed safety guidelines (known as the Metrics) for lettuce and other leafy green crops. The Metrics addressed encroachment and crop contamination by wildlife and livestock. Although not specifically mentioned in the Metrics, rodents are treated by growers and buyers as suspects in the food-borne illness complex. This has resulted in many unnecessary, ineffective, and expensive rodent control practices in leafy green crops. The Metrics require periodic monitoring of animal activity in and around the crop fields, but there are no specific guidelines on how to monitor for rodents. Specific objectives for this project were to: 1) identify the issues and requirements growers must address, particularly those demanded by buyers of leafy green crops, regarding rodent encroachment in leafy green crops; 2) identify the rodent species that live in and around leafy green crops; 3) develop monitoring strategies for rodents; 4) develop training materials on monitoring rodents.

We contacted major buyers of leafy green crops to obtain information on what they require from growers regarding rodent control. The information provided was varied. However, assessment of rodents in leafy green crops is clearly a priority for buyers with many producing written guidelines for growers. Visual monitoring and traps were the most consistent response.

We conducted fieldwork in the Salinas Valley region of Monterey County from May 2009 through June 2010. We surveyed 10 iceberg lettuce and 4 spinach fields to identify the rodents present and test rodent monitoring techniques. We surveyed each field during a period 7 to 14 days before harvest and again 1 to 6 days prior to harvest. We checked wax blocks, wax tags, and snap traps over a 3-day period along transects set up along the crop edge and the adjacent wild edge (wild vegetated area alongside the crop, often separated by a road). We also conducted visual surveys from a vehicle and on foot. We calculated an index of abundance (IA) to provide a measure of relative abundance. We combined control strategies from the California Vertebrate Pest Control Handbook (2008) with the results of the monitoring programs to produce a pocket manual specific to rodent monitoring in and around leafy green crops.

Visual surveys indicated no California ground squirrels (*Spermophilus beecheyi*) on any site, but pocket gophers (*Thomomys* spp.) were present on 11 of 14 sites along the wild edge adjacent to the crop, but in-crop at only 2 of 14 fields. We observed small rodent burrows and runways along the wild edge, but never in-crop. For all fields we trapped 17 mice in-crop and 51 mice along the wild edge. Deer mice and brush mice (*Peromyscus* spp.) were most commonly caught (15 in-crop and 33 along the wild edge), with house mice (*Mus musculus*) the next most abundant (2 caught in-crop and 15 along the wild edge). Wax blocks had the greatest amount of chewing activity both in-crop and along the wild edge at 10.2% and 36.3%, respectively. Wax tags were less preferred, showing activity

levels of 1.1% in-crop and 6.6% along the wild edge. The catch levels for snap traps at 1.7% in-crop and 5.4% along the wild edge were similar to the chewing activity for wax tags. In 15 of 27 (56%) surveys in-crop and in 28 of 28 (100%) surveys along the wild edge, the wax blocks had higher IA values compared to the wax tags or snap traps. In most cases the IA values decreased, stayed the same, or increased only slightly from the 1st to the 2nd survey. Wax blocks and to a lesser degree, wax tags, were subject to feeding by snails, but that feeding could be differentiated from feeding by rodents. Wax tags melted at temperatures >80^{0}F. To monitor rodents in leafy green crops, we recommend visual surveys for ground squirrels and gophers, and snap traps and wax blocks for mice. We suggest 1 survey conducted 2 to 3 weeks prior to harvest is sufficient to assess mouse presence and relative abundance in leafy green crops. We provide guidelines on how to conduct the surveys, a sample datasheet, and examples of IA calculations.

We reviewed the Metrics and identified all portions related to rodents and rodent control. Monitoring techniques were evaluated for their practicality and ability to detect rodents. Control strategies from the California Vertebrate Pest Control Handbook (2008) were combined with the results of the monitoring program to create a field guide containing relevant monitoring and control information regarding rodents and leafy green production. This booklet consists of 15 pages front and back containing picture references and a list of helpful website links.

Keywords: index of abundance, leafy greens, lettuce, rodent monitoring strategies, snap traps, spinach, wax block, wax tag

Introduction

Background: The safety of the food supply is a primary consideration of farmers, wholesale and retail establishments, and ultimately consumers. While past food safety efforts related to rodents and rodent control have primarily focused at the food processing level, recent food safety outbreaks have attracted more attention to farm production activities. Since 1995 there have been 20 outbreaks of food-borne illness in the U.S. from *Escherichia coli* O157:H7 on leafy greens such as spinach (RCDMC 2007). In 2006, a major outbreak of food-borne illness caused by *Escherichia coli* O157:H7 contaminated bagged spinach resulted in 3 deaths and over 200 illnesses (Beretti and Stuart 2008). The contaminated product was traced to bagged leafy green spinach from Central California.

As a result, in 2007, produce industry representatives with oversight from CDFA, developed the *Commodity Specific Food Safety Guidelines for the Lettuce and Leafy Greens Supply Chain*, known as the Metrics. The guidelines focus on the entire production operation from farm to packaging and distribution with the goal of minimizing microbial contamination. One issue specifically addressed in the guidelines is encroachment by animals (e.g., livestock, deer, wild pigs). Growers are advised to determine whether or not to harvest portions of a field with signs of wildlife pest activity (e.g., damaged crop, wildlife feces). In addition, buyers and shippers can and do impose additional requirements on growers as a condition of buying their crop.

Rodents are not mentioned as species of concern in the Metrics nor has research established a strong link between rodents and contamination of leafy green crops in the field. Until the actual link, or lack thereof, is identified, growers, shippers/buyers and others are treating rodents as suspects in the food-borne illness complex. Growers, in some cases, have been told by buyers to eliminate rodents without any proof that rodents are actually present.

Description and Extent of the Problem: Growers must comply with the Metrics and the various interpretations of the Metrics imposed by buyers to ensure their crop is safe for consumption. The response by growers to these requirements has been significant. A recent survey of growers in the Central Coast region of California indicated that of the 140,000 acres managed by the respondents, management activities to deter or eliminate wildlife has occurred on 133,000 acres (RCDMC 2007). Activities targeting rodents include the use of bait stations and poison baiting on 108,283 acres and bare ground buffers on 91,890 acres. There are significant efficacy and environmental risks with this large number of treated acres.

1. The target rodent pest species is generally unknown to the growers (D. Huss, personal communication). Generally growers do not identify the species or know the specific habits of the animals being targeted. It is difficult to select a suitable control strategy when the target species is unknown.
2. Inappropriate or unnecessary control techniques are being used by growers. For example, traps are being used as a direct control

technique. It is hard to imagine trapping as an effective approach to prevent rodents from entering leafy green crops.
Some processors are requiring a bait station every 50 ft. It is a common sight in the central coast growing region to see field borders lined with PVC bait stations. Bait stations designed for ground squirrels placed at 50-ft intervals represent an excessive use of bait that can result in increased hazards to other wildlife (Salmon 2007). A ground squirrel bait station is not necessarily the best design for smaller rodents. The costs for the bait and bait stations at 50-ft intervals are unnecessarily huge.

3. Buffer strips (bare ground strips) are being used as a means to prevent rodent movement into crops. However, little is known about the size of the strip needed and in many cases the buffer strips are maintained around the crops without knowing the target species. Without knowing the target species and the strip size needed to provide separation, this approach may be creating significant vegetation-free areas that have little impact on potential crop contamination.
4. According to the Metrics, growers must conduct periodic monitoring (pre-season, pre-harvest, and harvest assessments) of animal activity in and around the crop fields. Presently there are no specific guidelines on how to monitor for rodents.

Previous Research: Research is currently in progress by researchers from the University of California Veterinary School regarding the role of rodents in the transmission of *E. coli* to humans via food crops. Results from this research are not currently available.

Current Control Techniques: Growers currently employ traps, poisons, and habitat management to reduce rodent populations or prevent movement into the crop. As noted above, these techniques are sometimes inappropriate, unnecessary, or applied without knowledge of the target species.

Objectives: The overall goal of this project is to develop a systematic approach for monitoring and controlling rodents in and around leafy green crops. Specific objectives include:

1. Identify the current issues and requirements that growers must address regarding rodent encroachment in leafy green crops. This would include not only the guidelines specified in the Metrics that might apply to rodents. But more importantly the rodent control management demanded by the major buyers of leafy green crops.
2. Identify the rodent species that live in and around leafy green crops. The rodent complex that could occur may vary by crop or location.
3. Develop monitoring strategies to address rodents in and around leafy green crops.
4. Develop training materials for growers on managing rodents in and around leafy green crops.

Study Areas

Fieldwork was conducted in the Salinas Valley region of Monterey County from May 2009 through June 2010. Ten iceberg lettuce and 4 spinach fields (Table A) were surveyed for rodent presence and to test rodent monitoring techniques. All of the fields bordered habitat that could harbor rodents. We referred to this habitat as the "wild edge".

Methods

Objective 1 - Current issues and requirements:

We contacted major buyers of leafy green crops to obtain information on what they require from growers regarding rodent control. We conducted site visits to meet with growers to identify rodent issues related to leafy green crops. We reviewed the Metrics to identify portions that related to rodents and rodent control.

Objective 2 - Identify rodent species living in and around leafy green crops:

We identified rodents in leafy green crops and adjacent lands during 2 site inspections at each field, during a period 7 to 14 days prior to harvest and 1 to 6 days prior to harvest. These time periods roughly correspond to the pre-harvest and harvest inspections suggested in the Metrics. The pre-planting and post-harvest inspections suggested in the Metrics were not undertaken as we considered such inspections non-productive. Harvested fields were typically plowed under soon after harvest and reworked several times in preparation for replanting, leaving only bare soil, no rodent presence, and no reason for rodents to invade.

We used direct observation of pest animals or signs (e.g. burrows, mounds, trails, damage) as the technique to detect the presence of California ground squirrels (*Spermophilus beecheyi*) and pocket gophers (*Thomomys* spp.). As ground squirrels are diurnal and active above ground during the day, we scanned for squirrels as we drove our vehicle on and off site. We searched for visual signs of squirrels and other rodents by walking the perimeter of the field (usually along a farm road that bordered the field) one time; walking alongside or in the wild edge that bordered the field; and by walking across the field through the crop on at least 2 occasions during each inspection period. We noted the occurrence of any animals, burrows, tracks, mounds, trails, or droppings.

We used mouse-sized snap traps (Fig. 1) to reveal the presence and identity of small rodents such as voles (*Microtus* spp.), house mice (*Mus musculus*), and deer mice (*Peromyscus* spp.). The snap traps were also evaluated as a monitoring technique. The manner in which the traps were set and checked is described below under objective 3.

Objective 3 - Monitoring strategies:

We evaluated 4 techniques for monitoring rodent populations. Two of the techniques, direct observation and snap trapping, as noted above also served to identify the species of rodents present in the field. The 2 remaining techniques, wax blocks and wax tags, served to indicate the presence and relative abundance of rodents in the field

The wax blocks (Fig. 2), known as Detex Blox, were commercially available from Bell Labs. The wax block is non-toxic and made from 16 human food-grade ingredients. It is intended to detect the presence of rats or mice and is typically put out at intervals inside or around the outside of a building. Feeding on the wax block indicates the presence of a rodent.

The wax tag (Fig. 3) is commercially available from Pest Control Research in New Zealand (www.pestcontrolresearch.com). It was designed to monitor the presence of the brushtail possum (*Trichosurus vulpecula*), which is a vector for bovine tuberculosis. It is also used to detect the presence of rats or mice on tropical islands where sea birds nest. An animal that chews on the wax will leave tooth marks on the wax tag, which in some cases can be identified to species. The plastic tag is intended to enhance visibility (for the possum) and also permits the tag to be nailed to a tree, which puts it out of reach of non-target species. These features are not considered important for rodent use of the wax block. However, the wax is impregnated with a peanut butter scent, which is highly attractive to rodents. Unlike the snap trap, both the wax tag and the wax block pose no danger to non-target species.

Monitoring procedures: We used snap traps, wax blocks, and wax tags to determine the presence or absence and the relative abundance of rodents in leafy green crops and adjacent lands during 2 periods at each field, the period 7 to 14 days prior to harvest and the period1 to 6 days prior to harvest. At each site we established 2 transects, one along the edge or up to 5 ft (1.5 m) into the crop and the second along the wild edge or up to 5 ft (1.5m) into the wild edge adjacent to the transect in the crop. The 2 transects were in all cases separated by a dirt road used by farm vehicles.

We established monitoring stations at approximately 20-foot intervals (6.1 m) along each transect. The stations were set up in an alternating fashion, with one station consisting of a wax block and a wax tag, then the next station consisting of a snap trap. We set out a total of 20 wax blocks and wax tags each and 20 snap traps along each transect. We used a wire stake with a vinyl flag to pin each wax block and wax tag to the ground. The wax tags and wax blocks were located a minimum of 20 inches (51 cm) apart. We stuck a wire stake with a flag next to each snap trap. We used peanut butter to bait the snap traps. If any rodent sign was observed (e.g., a runway, burrow), then the trap or wax item was placed appropriately to enhance the likelihood of capture or use.

The stations were set up during the morning or early afternoon of day 1 and then checked for any activity in the morning on days 2 and 3. The stations were

removed after the day 3 check. For the snap traps we recorded the species of rodent caught (if any), whether the bait had been taken without springing the trap, or was the trap sprung with no catch. We rebaited and reset traps as needed for the next day's check. We examined the wax blocks and wax tags for any sign of chewing or feeding by rodents, as evidenced by marks from the rodents' incisors. On day 2, we lightly marked the chewed areas of the wax blocks with a black Sharpie pen. This allowed us to identify any new chewing when the blocks were checked on day 3. We used our fingers to smooth out any signs of chewing on the wax tags, as the wax was pliable and easily molded to cover over the incisor marks.

We calculated an index to rodent abundance (IA) following Caut *et al.* (2007). This calculation took into account the number of corrected trap nights (Nelson and Clark 1973). The calculation was: IA = 100 x captures/(TN-S/2), where TN = P x T. P is the number of trapping intervals, T is the number of traps, S is the total number of traps sprung (but without any catch), TN is the number of trap nights, and TN - S/2 is the number of corrected trap nights. With regard to the wax blocks and wax tags, "captures" in the above calculation would refer to the number of blocks or tags that had been chewed on. Also, a missing wax block or wax tag (e.g., taken away by a coyote or raccoon) would be analogous to a sprung trap. For comparative purposes, we calculated an IA value for each item (snap trap, wax block, wax tag) for each transect (in crop, wild edge) for each sampling period (7 to 14 days before harvest, 1 to 6 days prior to harvest). If there were no sprung traps or missing wax blocks or wax tags, the IA value could range from 0 to 100 (Table B).

Objective 4 - Training materials:

We combined control strategies from the California Vertebrate Pest Control Handbook (2008) with the results of the monitoring programs to produce a manual specific to rodent control in and around leafy green crops.

Results

Objective 1 - Current issues and requirements:

A number of buyer and shipper organizations in the Salinas valley area were contacted and information was requested about any potential requirements of growers relating to rodent control in leafy green crops. The information gathered did not show a pattern. In summary it appears at this time that each buyer/ processor institutes individual requirements for growers. There are some consistent items and they are summarized in the points below:

1. All buyers/shippers contacted stated that they conduct at a minimum pre harvest crop inspections using visual monitoring. Some stated they also conduct pre season and also continuous visual monitoring programs in their potential crop purchases.

2. Inspections examine for rodent damage i.e. chewing on crop, droppings, nesting. When assessing rodent populations buyers look at prior history of the field, garbage accumulation, buffer zones, and how the grower is approaching control pre-season.
3. Trapping was the most common control method used in season, with off-season bait use.
4. Eliminating nesting sites by requiring irrigation pipes to be stored on racks above ground level.
5. Where evidence of rodent activity is detected buyers may exclude portions or an entire crop.

In conclusion, it appears all buyers are actively addressing rodent activity in leafy green crops. A systematic monitoring approach is recommended to assist growers in meeting buyers/ shippers requirements.

Objective 2 - Identify the rodent species:

We conducted visual surveys and used snap traps on 14 sites. Visual surveys indicated no ground squirrels or ground squirrel burrows in or around any of the fields (Table C). With the exception of 2 fields, pockets gophers were not present in-crop. In the 2 fields where we observed gopher mounds, the infestation appeared light, consisting of limited areas with <5 mounds each. Gopher sign, however, was common in the wild edge adjacent to the crop sites. We found gopher mounds in the wild edge at 11 of 14 sites. We did not find any evidence (e.g., burrows, runways) of mice inhabiting any of the crop sites. Mouse-sized burrows or runways were found in the wild edge at 12 of 14 sites.

Mice were trapped both in-crop and in the wild edge (Table D). In 27 sampling periods, no mice were trapped in-crop during 14 sampling periods. Low numbers of mice, usually 1 or sometimes 2 mice, were trapped in-crop during 13 sampling periods. No mice were caught in the wild edge during 13 of 28 sampling periods. In comparison to the in-crop trapping, relatively large numbers of mice (e.g., 7 to 9 mice per sampling period) were caught along the wild edge during 4 sampling periods. Overall, 17 mice were caught in-crop, while 51 were caught along the wild edge. Deer mice and brush mice (*Peromyscus* spp.) were the most frequently caught mice, with 15 caught in-crop and 33 caught along the wild edge. House mice were the next most abundant species, with 15 mice caught along the wild edge at 4 sites but only 2 caught in-crop at 2 sites. Only 3 voles were trapped, all taken along the wild edge.

In terms of changes in the number of mice caught in snap traps from the 1st sampling period to the 2nd sampling period, in 10 out of 13 cases the catch in-crop remained the same or decreased (Table E). For the wild edge the catch remained the same or decreased in 9 out of 14 cases. Combining the trap catch data for in-crop and wild edge surveys, in the 8 cases where the catch increased from the 1st sampling period to the 2nd sampling period, the increase was only 1 mouse in 6 of the 8 cases. This illustrates that in most cases there was a decrease, no change, or only a small increase in mouse populations from the 1st

to 2nd sampling period, which calls to question the value of the 2nd sampling period undertaken only 1 week after the 1st sampling period.

Objective 3 - Monitoring strategies:

We evaluated visual surveys, wax blocks, wax tags, and snap traps as techniques to monitor rodent populations in and around 14 sites. The results from visual monitoring are provided above under results for objective 2. Data on the number of items chewed, sprung, or missing, and the rodent catches are provided for 2 sampling periods for each site in Table F. These data are summarized in Table G. The wax blocks had the greatest amount of chewing activity both in-crop and along the wild edge at 10.2% and 36.3%, respectively (Table G). In comparison, the wax tags were less preferred, with activity levels of 1.1% in-crop and 6.6% along the wild edge. The catch levels for snap traps at 1.7% in-crop and 5.4% along the wild edge were similar to the chewing activity for wax tags.

Regarding IA values, in 15 of 27 (56%) surveys in-crop and in 28 of 28 (100%) surveys along the wild edge, the wax blocks had higher values compared to the wax tags or snap traps (Table H). As the average IA values are based on the number or items chewed or mice caught with a correction for trap nights, the calculated IA values are nearly identical to the percentage rankings above (see Table G to compare): wax blocks: 10.2 in-crop, 36.9 along the wild edge; wax tags: 1.1 in-crop, 6.6 along the wild edge; snap traps: 1.6 in-crop, 5.4 along the wild edge. The highest individual IA values were: wax blocks: 55.0 in-crop, 80.0 along the wild edge; wax tags: 7.5 in-crop, 32.5 along the wild edge; snap traps: 5.1 in-crop, 30.8 along the wild edge.

Regarding changes in IA values from the 1st sampling period to the 2nd sampling period, for all items both in-crop and along the wild edge, the IA values, with 1 exception, either decreased or stayed the same in the majority of cases (Table I). For example, IA values for wax blocks decreased or stayed the same in-crop in 9 of 13 cases, or decreased or stayed the same for snap traps in 9 of 14 cases along the wild edge. The exception was wax blocks along the wild edge, where the IA values decreased or stayed the same in only 3 of 14 cases.

The wax blocks and to a much lesser degree the wax tags were fed upon by snails (unknown species) at several sites, particularly those that bordered the slough (Table J). The snail activity occurred along the wild edge, never in-crop. Snail feeding could be differentiated from rodent feeding. Snail feeding looked like smooth shallow scoops in the wax block compared to the jagged incisor marks left by rodents. Snails typically left a slime trail on or around the wax blocks, which also indicated their presence. Rodent feeding usually, but not always, resulted in “crumbs” on the ground around the wax block. Snail feeding did not result in crumbs on the ground.

The wax tags were impacted by weather conditions. Eight wax tags either melted or partially melted during the 13 - 15 July 2009 sampling period at Field 6. The high temperature in Salinas reached 88^{o} F (31^{o} C) during that period.

Objective 4 - Training materials:

We reviewed the Metrics and identified all portions related to rodents and rodent control. Identifying rodent presence in leafy green crops and adjacent lands during each phase of production.

Monitoring techniques were evaluated for their practicality and ability to detect rodents. Control strategies from the California Vertebrate Pest Control Handbook (2008) were combined with the results of the monitoring program; information from major buyers of leafy green crops and rodent issues, to develop a monitoring guide. We worked with growers and others to identify what monitoring methods would be practical and useful to comply with the leafy green Metrics. We synthesized that data into a field guide containing relevant monitoring and control information regarding rodents and leafy green production.

These training materials were developed with easy to follow instructions based on the “Recommendations for a Rodent Monitoring System” section listed in this document, accompanied by informational pages on commonly occurring pest species and how to identify them. These materials are presented as a pocket sized (5”x4”), laminated, and bound guide. The lamination allows the guide to be used in the field as a quick reference and space has been left on each page to allow for notes to be taken using an erasable marker. The booklet consists of 15 pages front and back containing picture references and a list of helpful website links.

Discussion

Whisson and Engeman (2003) examined various indexing techniques to measure relative abundance of meadow voles, a common pest in artichokes. They concluded that wax blocks provided the most sensitive index measurements and were logistically the easiest to use. This study attempted develop a monitoring system based on the findings of Whisson and Engeman, but one that avoided the complicated computations used by Whisson and Engeman that were best suited to scientific research rather than “real world” situations. Thus, our goal was to develop a monitoring system that identified the species of rodents present, and provided an index to relative abundance that was practical, easy to apply and to interpret.

We evaluated 4 techniques, wax blocks, wax tags, snap traps, and visual surveys. The wax blocks and wax tags provided different information than the snap traps and visual surveys. The wax blocks and tags only indicated the presence or absence of small rodents (e.g., mice). The snap traps and visual surveys indicated the presence of rodents, but more importantly the species of rodent that were present. Visual surveys could effectively detect large rodents

(e.g., ground squirrels, pocket gophers) both in-crop and along the wild edge, but were not effective in detecting small rodents in-crop. We suspect that the mice detected in-crop by the wax items or the snap traps were living in the wild edge. Thus there would be no sign (e.g., burrows, runways) of small rodents to be detected by visual surveys in-crop. The visual surveys and snap trapping complimented each other, with the snap traps essential to small rodent detection and identification.

In comparing the wax blocks to the wax tags, it is apparent the wax blocks were preferred by small rodents and were superior at detecting small rodents. Other factors favor the wax block. The wax block at ~$0.41 each is less expensive that the wax tag at ~$1.00 each (2008 prices). The wax block does not melt at high temperatures unlike the wax tags, several of which melted at the relatively low temperatures in the mid- to high 80^0s. In regions with higher temperatures the number of melting failures would be greater.

We did not conduct surveys while the fields were being irrigated because we thought the sprinkle irrigation might degrade the wax blocks, wash the peanut butter off the traps, or inhibit rodent foraging. On several occasions we requested that irrigation be delayed until our surveys were completed. However, rain, heavy at times, fell on 27 May during the surveys of fields 12, 13, and 14. We did not observe any degradation of the wax blocks or of the peanut butter bait on the traps as a result of the rain. Nonetheless, we suggest that surveys should be conducted during dry periods (e.g., no sprinkle irrigation or rain).

We conducted the surveys during 2 periods at each field, the period 7 to 14 days prior to harvest and the period 1 to 6 days prior to harvest. We initially timed the surveys to follow the guidelines for wildlife surveys recommended in the Metrics. However, when comparing the number of mice caught or the IA values from the 1^{st} to the 2^{nd} survey, we found a decrease, no change, or only a small increase in the number of mice (n = 1) or IA values (IA #2.5) in the majority of cases. This suggests there is little additional information to be gained from the 2^{nd} survey and therefore it is unnecessary. In addition, from a control standpoint, if there was a significant increase in IA values from the 1^{st} to the 2^{nd} survey to the point where control actions were deemed necessary, there would be little time left before harvest to significantly reduce damage. We suggest that only 1 survey for small rodents using wax blocks and snap traps is necessary, and that it should be conducted 2 to 3 weeks before harvest. Visual surveys for ground squirrels and pocket gophers should be undertaken on a regular basis throughout the crop cycle and should begin no later than the time of germination.

It is apparent from the surveys that there are more rodents in the wild edge than in-crop. However, high numbers of small rodents along the wild edge did not translate into high numbers or damage in the crops. Based on in-crop visual surveys there were no small rodents living in any of the fields we surveyed. We suspect that any small rodent activity in the fields resulted from animals that lived in the wild edge and crossed over the service road, primarily during the night, to access the crop or the field. We did not observe any crop damage from small

rodents in the fields we surveyed. Given that the animals may enter the crop at different locations every time (rather than via established runways) and due to the dense growth and leafy nature of lettuce and spinach, it would be difficult to identify any damage if it were present.

A pertinent question is what IA value warrants control action? As noted above, a high IA from the wild edge does not necessarily mean that small rodents are entering the crop or that there is damage. However, if the in-crop IA exceeds an established threshold, then control action is warranted. The threshold could be based on pest tolerance (e.g., no mice can be tolerated in the crop), economic factors (e.g., weighing the value of costs versus benefits), or health and safety factor (potential disease transmission). Once the threshold has been reached, then control actions would be undertaken in the wild edge as it represents the source of small rodents entering the crop.

The IA represents relative abundance but does not indicate that rodents are living in crop. Therefore there is no specific threshold IA that can be used to initiate a control program. In reviewing our data we feel that an IA 7 or below indicates a low occurrence of rodents, likely transient to the area. The risk of contamination is low and no control appears necessary. An IA above 7 warrants greater scrutiny of the monitoring site. If this examination indicates the presence of rodents (e.g. burrows, trails, or damage) control is recommended.

Rodenticides cannot be used in crops, so the presence of rodent damage while unlikely according to our research may require that the crop area not be harvested. In the adjacent wild edge areas control should be initiated in those areas where rodents are present (e.g. burrows, trails, damage). We recommend controlling along the field edge (outside the crop) and if possible at least 15’ into the rodent habitat.

Recommendations for a Rodent Monitoring System

The rodent monitoring system described below is based on results from the field surveys conducted in 2009 and 2010. There are 2 components to the monitoring system, the visual survey for larger rodents, and the wax block/snap trap survey for small rodents.

Visual Survey

Target species: Primarily California ground squirrels and pocket gophers; secondarily small rodents.

When: Prior to planting, a visual survey should be conducted while driving vehicles on and off site; when starting the wax block/snap trap survey 2 to 3 weeks before harvest.

Materials required: Ranch map or notebook for recording observations.

Survey procedure: Ground squirrels are active above ground during the day. If present they can be detected from a distance running in and out of the crop. Ground squirrels are colonial; several burrows will usually be located together. Burrows will be located in the wild edge. Scan for squirrels in the distance when driving on or off site. Record the presence of squirrels or burrows on a ranch map or in a notebook.

Pocket gophers live underground. Their burrowing activity produces mounds of dirt. Mounds can often be seen from a vehicle while driving. A vehicle provides a high vantage point that is useful for scanning the interior of a field for mounds. Scans for mounds can be undertaken when driving on or off site.

Gopher mounds can also be spotted when walking. A walking search for mounds may be conducted while setting up the wax block-snap trap survey (described below) 2 to 3 weeks prior to harvest. Walk along or in the wild edge that borders the field; look for any mounds or plugged feedholes. Then, walk along the entire outside edge of the field, paying particular attention to the first 20 - 30 feet into the field. Record the location of any mounds.

Small rodents (e.g., mice) may be detected while walking along the wild edge and the field perimeter. Small burrow openings, runways between burrows or in the vegetation, tracks in the mud, and droppings are signs of small rodents. Record the general location of any burrows, runways, or other small rodent sign.

Wax Block-Snap Trap Survey

Target species: Small rodents including deer mice, house mice, and voles.

When: 2 to 3 weeks before harvest.

Materials required: Ranch map or notebook for recording location of transects; data sheets for recording survey results; mouse-sized snap traps (40 plus spares to replace broken or missing traps); a bucket for carrying the traps and wax blocks; peanut butter for bait; knife to apply peanut butter to the trap; wax blocks (40 initially with reserve of at least 20 per survey to replace chewed or missing blocks); Sharpie pen; wire flags (80 plus spares); latex gloves, rubber gloves, disinfectant.

The non-toxic wax blocks, called Detex Blox, are commercially available from Bell Labs. *Survey procedure:* Conduct the survey 2 to 3 weeks prior to harvest. Establish 2 transects, the first along the crop edge (up to 5 ft into the crop) and the second along the wild edge and up to 5 ft into the wild edge (wild vegetated area alongside the crop, often separated by a road). Setup monitoring stations at approximately 20-foot intervals along each transect. Set up the stations in an alternating fashion, with one station consisting of a wax block, then the next station 20 ft away consisting of a snap trap. Set out 20 wax blocks and 20 snap traps along each transect. Use a wire stake with a vinyl flag placed through the hole in the wax block to pin it to the ground. Stick a wire stake with a flag into the ground next to each snap trap. Bait each trap with peanut butter applied with a knife. If any rodent sign is observed (e.g., a runway, burrow), then place the trap

or wax block in the runway or next to the burrow to enhance the likelihood of capture or use.

Set up the stations during the morning or early afternoon of day 1. Check the stations for any activity in the morning on days 2 and 3. To minimize exposure to rodents and their droppings wear latex gloves and wash hands thoroughly after handling traps, wax blocks, and/or dead rodents. For further information visit http://cdc.gov. Remove the stations after the day 3 check. For the snap traps record the species of rodent caught (if any), if the trap was sprung with no catch, or if the trap is missing. Dead rodents can be disposed of in plastic bag in the trash or buried outside of the crop area. Rebait and reset the traps as needed for the next day's check. Replace any missing traps. Examine the wax blocks closely for any sign of chewing or feeding by rodents, as evidenced by marks from the rodents' teeth and crumbs left on the ground around the wax block. The tooth marks and feeding can be very obvious and extensive or may consist of only 2 tooth marks. On day 2, if the feeding on the wax block was extensive, replace the old block with a new one. If the feeding is not so extensive, then lightly mark the chewed areas of the wax blocks with a black Sharpie pen. This allows identification of any new chewing when the blocks are checked on day 3. Record the results from each day's check on a data sheet (see Appendix 2 for an example). After checking the stations on days 2 and 3, remove and dispose of the latex gloves, wash hands with soap and water.

Watch for snail or slug feeding on the wax blocks. Snail feeding is most likely to occur along the wild edge, particularly if water is present. Snail feeding can be differentiated from rodent feeding. Snail feeding looks like smooth scoops in the wax block compared to the jagged incisor marks left by rodents. Snails typically leave a slime trail that glistens on or near the wax blocks. Snail feeding does not leave crumbs on the ground. Be aware that it is possible to have both rodent and snail feeding on 1 block.

On day 3, remove all flags and place the snap traps in a bucket after checking each station. The wax blocks may be left on site or placed in the bucket. Later, while wearing rubber gloves put the wax blocks in a plastic bag and dispose of it. Fill the bucket with the snap traps with a solution of water and disinfectant (1% household bleach or 5% hospital-type bulk Lysol). Let the traps soak for 15 minutes, then rinse them off with a high-pressure hose. Be sure to remove any peanut butter bait remaining on the trap. Rinse out the bucket. Then wash gloved hands with soap and water or a suitable disinfectant (1% household bleach, 5% hospital-type bulk Lysol). Keep the washed, rubber gloves for future use. Next, wash hands thoroughly with soap and water immediately after removing the rubber gloves.

Index of Abundance Calculations:

See Appendix 3 for a worksheet to calculate index of abundance (IA) values for the 2-day period for snap traps and wax blocks in each transect.

$$IA = 100 \times C/(TN-S/2)$$

TN (trap or wax block nights) = P x T

Where:

P = the number of sampling intervals

T = the number of traps or wax blocks for each interval

S = number of missing traps or traps sprung with no catch, or the number of missing wax blocks.

C = number of mice captured or the number of wax blocks chewed on by rodents.

If there are no sprung traps or missing wax blocks, the IA value could range from 0 to 100.

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Tables and Figures

Figure 1. Mouse-sized snap traps used to catch small rodents in and around iceberg lettuce and spinach fields in Monterey County in 2009 and 2010.

Figure 2. Wax blocks used to indicate the presence of small rodents in and around iceberg lettuce and spinach fields in Monterey County in 2009 and 2010.

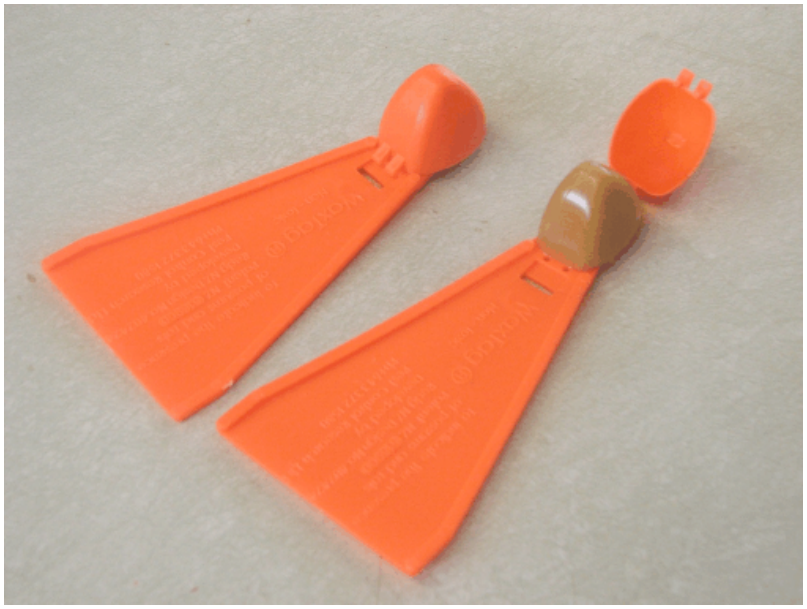


Figure 3. Wax tags used to indicate the presence of small rodents in and around iceberg lettuce and spinach fields in Monterey County in 2009 and 2010. The plastic cover of the tag on the right has been opened to reveal the wax tab with peanut butter attractant.

Table A. Descriptions of spinach and iceberg lettuce fields surveyed for rodents during the period from May 2009 through June 2010 in Monterey County, California.

Location[a]	Field Name	Crop	Dates Surveyed	Area[b]	Description of Wild Edge
Salinas	Field 1	Iceberg lettuce	5/11-13/09 5/27-29/09	5.9	Borders a slough with flowing water. Sparse to thick growth of various herbaceous plants including bur-reed (*Sparganium* spp.) and cattail (*Typha* spp.) along the water's edge.
Salinas	Field 2	Iceberg lettuce	5/11-13/09 5/27-29/09	11.3	Borders a slough with flowing water. Sparse to thick growth of various herbaceous plants along the water's edge.
Salinas	Field 3	Iceberg lettuce	6/17-19/09 6/24-26/09	10.2	Borders a slough with flowing water. Plant growth similar to above but taller and denser than in May.
Salinas	Field 4	Iceberg lettuce	6/24-26/09 6/30-7/2/09	10.4	Borders a slough with flowing water. Plant growth similar to above but taller and denser than in May.
Salinas	Field 5	Iceberg lettuce	6/30-7/2/09 7/13-15/09	8.0	Borders a slough with flowing water. Sections of shoreline and banks devoid of vegetation. Strip of existing vegetation along shoreline was narrow and not continuous.
Chular	Field 6	Spinach	7/7-9/09 7/13-15/09	10.0	Borders riparian zone of Salinas River with dense stands of shrubs, trees, and herbaceous undergrowth.
Castroville	Field 7	Spinach	8/12-14/09 8/18-20/09	5.5	Shrubs interspersed with grass and other herbaceous growth along edge of Highway 1.
Castroville	Field 8	Iceberg lettuce	9/23-25/09 9/30-10/2/09	15.9	Shrubs interspersed with grass and other herbaceous growth along edge of Highway 1.
Castroville	Field 9	Iceberg lettuce	9/23-25/09 9/30-10/2/09	6.4	Shrubs interspersed with grass and other herbaceous growth along edge of Highway 1.
Chular	Field 10	Spinach	3/14-16/10 3/22-24/10	8.0	Borders riparian zone of Salinas River, mainly grass and forb cover interspersed with shrubs.
Chular	Field 11	Spinach	3/14-16/10 3/22-24/10	6.0	Borders riparian zone of Salinas River with dense growth of shrubs and trees.
Salinas	Field 12	Iceberg lettuce	5/19-21/10 5/26-28/10	7.2	Borders a slough with flowing water. Sparse to moderate cover consisting mostly of bur-reed along waters' edge.
Salinas	Field 13	Iceberg lettuce	5/26-28/10 6/2-4/10	13.5	Borders a slough with flowing water. Moderate to dense cover along waters' edge of bur-reed and cattail.
Salinas	Field 14	Iceberg lettuce	5/26-28/10 6/2-4/10	13.0	Borders a slough with flowing water. Moderate to dense cover along waters' edge of bur-reed and cattail.

[a]Nearest town or city.
[b]Approximate area of the field in acres.

Table B. Potential index of abundance (IA) values base on 0 to 40 trapped mice or chewed wax blocks or wax tags over a 2-day sampling period with 20 traps or wax items deployed each day. The calculated values assume no sprung traps, and no missing wax blocks or wax tags.

No. of captures or chewed items	IA	No. of captures or chewed items	IA
0	0	21	52.5
1	2.5	22	55
2	5	23	57.5
3	7.5	24	60
4	10	25	62.5
5	12.5	26	65
6	15	27	67.5
7	17.5	28	70
8	20	29	72.5
9	22.5	30	75
10	25	31	77.5
11	27.5	32	80
12	30	33	82.5
13	32.5	34	85
14	35	35	87.5
15	37.5	36	90
16	40	37	92.5
17	42.5	38	95
18	45	39	97.5
19	47.5	40	100
20	50	-	-

Table C. Results from visual surveys for rodents and rodent sign in spinach and iceberg lettuce fields during the period from May 2009 through June 2010 in Monterey County, California. B = burrows, M = mounds, R = runways.

	Dates	Ground Squirrels		Mice		Pocket Gophers	
Field Name	Surveyed	In Crop	Edge	In Crop	Edge	In Crop	Edge
Field 1	5/11-13/09	None	None	None	B	None	M
	5/27-29/09	-[a]	None	-[a]	B, R	-[a]	M
Field 2	5/11-13/09	None	None	None	B	None	M
	5/27-29/09	None	None	None	B, R	None	M
Field 3	6/17-19/09	None	None	None	B, R	None	None
	6/24-26/09	None	None	None	B, R	None	None
Field 4	6/24-26/09	None	None	None	B	None	M
	6/30-7/2/09	None	None	None	B	None	M
Field 5	6/30-7/2/09	None	None	None	B	None	None
	7/14-15/09	None	None	None	B	None	None
Field 6	7/7-9/09	None	None	None	B	None	M
	7/13-15/09	None	None	None	B	None	M
Field 7	8/12-14/09	None	None	None	R	None	M
	8/18-20/09	None	None	None	R	None	M
Field 8	9/23-25/09	None	None	None	R	None	M
	9/30-10/2/09	None	None	None	R	None	M
Field 9	9/23-25/09	None	None	None	None	None	None
	9/30-10/2/09	None	None	None	None	None	None
Field 10	3/14-15/10	None	None	None	B, R	M	M
	3/22-24/10	None	None	None	B, R	M	M
Field 11	3/14-16/10	None	None	None	None	None	M
	3/22-24/10	None	None	None	None	None	M
Field 12	5/19-21/10	None	None	None	B, R	M	M
	5/26-28/10	None	None	None	B, R	M	M
Field 13	5/26-28/10	None	None	None	B	None	M
	6/2-4/10	None	None	None	B	None	M
Field 14	5/26-28/10	None	None	None	B	None	M
	6/2-4/10	None	None	None	B	None	M

[a]No in-crop survey due to harvest operations.

Table D. Species[a] and numbers of animals snap trapped in spinach and iceberg lettuce fields during the period from May 2009 through June 2010 in Monterey County, California.

Field Name	Crop	Dates Surveyed	Species (#) In Crop	Species (#) Wild Edge
Field 1	Iceberg lettuce	5/11-13/09	Deer mouse(1)	None caught
		5/27-29/09	No trapping	None caught
Field 2	Iceberg lettuce	5/11-13/09	None caught	None caught
		5/27-29/09	None caught	House mouse (1)
Field 3	Iceberg lettuce	6/17-19/09	House mouse (1)	House mouse (1)
			Deer mouse (1)	Deer mouse (1)
		6/24-26/09	Deer mouse (2)	Vole (2)
Field 4	Iceberg lettuce	6/24-26/09	None caught	House mouse (4)
		6/30-7/2/09	None caught	House mouse (8)
				Deer mouse (1)
Field 5	Iceberg lettuce	6/30-7/2/09	Deer mouse (1)	None caught
		7/13-15/09	None caught	Vole (1)
Field 6	Spinach	7/7-9/09	Brush mouse (1)	Brush mouse (4)
		7/13-15/09	House mouse (1)	Brush mouse (6)
				House mouse (1)
Field 7	Spinach	8/12-14/09	None caught	None caught
		8/18-20/09	None caught	None caught
Field 8	Iceberg lettuce	9/23-25/09	None caught	Deer mouse (1)
		9/30-10/2/09	Deer mouse (1)	None caught
Field 9	Iceberg lettuce	9/23-25/09	Deer mouse (2)	Deer mouse (1)
		9/30-10/2/09	None caught	None caught
Field 10	Spinach	3/14-16/10	Brush mouse (1)	Brush mouse (2)
			Deer mouse (1)	
		3/22-24/10	None caught	None caught
Field 11	Spinach	3/14-16/10	Deer mouse (1)	Brush mouse (2)
				Deer mouse (5)
		3/22-24/10	Deer mouse (1)	Brush mouse (6)
				Deer mouse (2)
Field 12	Iceberg lettuce	5/19-21/10	None caught	None caught
		5/26-28/10	Deer mouse (1)	None caught
Field 13	Iceberg lettuce	5/26-28/10	None caught	Deer mouse (1)
		6/2-4/10	None caught	None caught
Field 14	Iceberg lettuce	5/26-28/10	None caught	Deer mouse (1)
		6/2-4/10	Deer mouse (1)	None caught
			3 = 17 in crop	3 = 51 wild edge

[a]Species: deer mouse (*Peromyscus* spp.), house mouse (*Mus musculus*), brush mouse (*Peromyscus boylii*), vole (*Microtus* spp.).

Table E. Changes in the numbers of mice trapped in-crop and along the wild edge from the 1st sampling period to the 2nd sampling period at 14 sites in Monterey County.

Location	Decrease	No change	Increase
In-crop	3	7	3
Wild edge	5	4	5

Table F. Number of wax blocks or wax tags with no activity, chewed by rodents, or missing, and the number of snap traps either sprung, missing, or with rodent catch in spinach and iceberg lettuce fields surveyed during the period from May 2009 through June 2010 in Monterey County, California.

	Dates		Wax Block		Wax Tag		Snap Trap	
Field Name	Surveyed	Results	In Crop	Edge	In Crop	Edge	In Crop	Edge
Field 1	5/11-13/09	No activity	40	38	40	40	38	34
		Chewed	0	2	0	0	-	-
		Sprung or missing	0	0	0	0	1	6
		Rodent catch	-	-	-	-	1	0
	5/27-9/09[a]	No activity	-	23	-	35	-	34
		Chewed	-	17	-	5	-	-
		Sprung or missing	-	0	-	0	-	6
		Rodent catch	-	-	-	-	0	0
Field 2	5/11-13/09	No activity	40	34	40	40	38	39
		Chewed	0	6	0	0	-	-
		Sprung or missing	0	0	0	0	2	1
		Rodent catch	-	-	-	-	0	0
	5/27-29/09	No activity	40	24	40	40	38	35
		Chewed	0	16	0	0	-	-
		Sprung or missing	0	0	0	0	2	4
		Rodent catch	-	-	-	-	0	1
Field 3	6/17-19/09	No activity	28	17	39	39	38	35
		Chewed	12	23	1	1	-	-
		Sprung or missing	0	0	0	0	0	3
		Rodent catch	-	-	-	-	2	2
	6/24-26/09	No activity	26	6	39	19	32	15
		Chewed	14	14	1	1	-	-
		Sprung or missing	0	0	0	0	6	3
		Rodent catch	-	-	-	-	2	2
Field 4	6/24-26/09	No activity	38	14	40	35	38	29
		Chewed	2	26	0	5	-	-
		Sprung or missing	0	0	0	0	2	7
		Rodent catch	-	-	-	-	0	4
	6/30-7/2/09	No activity	39	12	40	39	39	15
		Chewed	1	27	0	1	-	-
		Sprung or missing	0	1	0	0	1	15
		Rodent catch	-	-	-	-	0	9

Field 5	6/30-7/2/09	No activity	38	33	40	40	39	34
		Chewed	2	7	0	0	-	-
		Sprung or missing	0	0	0	0	0	6
		Rodent catch	-	-	-	-	1	0
	7/14-15/09	No activity	29	31	27	40	23	35
		Chewed	0	9	0	0	-	-
		Sprung or missing	1	0	3	0	17	4
		Rodent catch	-	-	-	-	0	1
Field 6	7/7-9/09	No activity	39	28	40	35	37	34
		Chewed	1	12	0	4	-	-
		Sprung or missing	0	0	0	1	2	2
		Rodent catch	-	-	-	-	1	4
	7/13-15/09	No activity	37	23	39	31	39	17
		Chewed	3	16	1	6	-	-
		Sprung or missing	0	1	0	3	0	16
		Rodent catch	-	-	-	-	1	7
Field 7	8/12-14/09	No activity	35	29	40	38	39	34
		Chewed	5	11	0	2	-	-
		Sprung or missing	0	0	0	0	1	6
		Rodent catch	-	-	-	-	0	0
	8/18-20/09	No activity	25	26	40	40	40	38
		Chewed	15	13	0	0	-	-
		Sprung or missing	0	1	0	0.	0	2
		Rodent catch	-	-	-	-	0	0
Field 8	9/23-25/09	No activity	18	34	37	40	40	38
		Chewed	22	6	3	0	-	-
		Sprung or missing	0	0	0	0	0	1
		Rodent catch	-	-	-	-	0	1
	9/30-0/2/09	No activity	39	34	39	39	34	40
		Chewed	9	6	1	1	-	-
		Sprung or missing	1	0	0	0	3	0
		Rodent catch	-	-	-	-	1	0
Field 9	9/23-25/09	No activity	28	33	39	39	37	39
		Chewed	12	7	1	1	-	-
		Sprung or missing	0	0	0	0	1	0
		Rodent catch	-	-	-	-	2	1
	9/30-0/2/09	No activity	34	38	37	39	29	40
		Chewed	3	2	0	1	-	-
		Sprung or missing	3	0	3	0	11	0
		Rodent catch	-	-	-	-	0	0

Field 10	3/14-16/10	No activity	40	31	38	36	37	37
		Chewed	0	9	2	4	-	-
		Sprung or missing	0	0	0	0	1	1
		Rodent catch	-	-	-	-	2	2
	3/22-24/10	No activity	40	28	40	37	40	36
		Chewed	0	12	0	3	-	-
		Sprung or missing	0	0	0	0	0	4
		Rodent catch	-	-	-	-	0	0
Field 11	3/14-16/10	No activity	35	13	38	27	39	20
		Chewed	5	27	2	13	-	-
		Sprung or missing	0	0	0	0	0	13
		Rodent catch	-	-	-	-	1	7
	3/22-24/10	No activity	39	8	40	29	37	21
		Chewed	1	30	0	11	-	-
		Sprung or missing	0	2	0	0	2	11
		Rodent catch	-	-	-	-	1	8
Field 12	5/19-21/10	No activity	40	36	40	39	40	36
		Chewed	0	4	0	1	-	-
		Sprung or missing	0	0	0	0	0	4
		Rodent catch	-	-	-	-	0	0
	5/26-28/10	No activity	40	32	40	40	39	
		Chewed	0	8	0	0	-	38
		Sprung or missing	0	0	0	0	0	-
		Rodent catch	-	-	-	-	1	2
								0
Field 13	5/26-28/10	No activity	39	27	40	35	37	29
		Chewed	1	13	0	5	-	-
		Sprung or missing	0	0	0	0	3	10
		Rodent catch	-	-	-	-	0	1
	6/2-4/10	No activity	40	22	40	37	35	25
		Chewed	0	16	0	3	-	-
		Sprung or missing	0	2	0	0	5	15
		Rodent catch	-	-	-	-	0	0
Field 14	5/26-28/10	No activity	40	8	40	38	38	32
		Chewed	0	32	0	2	-	-
		Sprung or missing	0	0	0	0	2	7
		Rodent catch	-	-	-	-	0	1
	6/2-4/10	No activity	38	14	40	38	37	31
		Chewed	2	26	0	2	-	-
		Sprung or missing	0	0	0	0	2	9
		Rodent catch	-	-	-	-	1	0

[a]No in-crop survey due to harvest operations.

Table G. Summary of data from Table F showing the number of wax blocks or wax tags with no activity, chewed by rodents, or missing, and the number of snap traps either sprung, missing, or with rodent catch in spinach and iceberg lettuce fields surveyed during the period from May 2009 through June 2010 in Monterey County, California.

	Wax Blocks		Wax Tags		Snap Traps	
Status	In Crop	Edge	In Crop	Edge	In Crop	Edge
No activity	964	696	1052	1024	997	890
Chewed or with catch	110	397	12	72	17	51
Percent chewed or with catch	10.2	36.3	1.1	6.6	1.7	5.4
Sprung or missing	5	7	6	4	64	158

Table H. Index of rodent abundance values for spinach and iceberg lettuce fields surveyed for rodents during the period from May 2009 through June 2010 in Monterey County, California.

		Index of Rodent Abundance					
		Wax Block		Wax Tag		Snap Trap	
Field Name	Dates Surveyed	Edge	In Crop	Edge	In Crop	Edge	In Crop
Field 1	5/11-13/09	0	5.0	0	0	2.5	0
	5/27-29/09	-[a]	42.5	-[a]	12.5	-[a]	0
Field 2	5/11-13/09	0	15.0	0	0	0	0
	5/27-29/09	0	40.5	0	0	0	2.6
Field 3	6/17-19/09	30.0	57.5	2.5	2.5	5.0	5.2
	6/24-26/09	35.0	70.0	2.5	5.0	5.3	5.2
Field 4	6/24-26/09	5.0	65.0	0	12.5	0	11.0
	6/30-7/2/09	2.5	68.4	0	2.5	0	30.8
Field 5	6/30-7/2/09	5.0	17.5	0	0	2.5	0
	7/14-15/09	0	22.5	0	0	0	3.6
Field 6	7/7-9/09	2.5	30.0	0	10.1	2.6	10.3
	7/13-15/09	7.5	41.6	2.5	16.6	2.5	21.9
Field 7	8/12-14/09	12.5	27.5	0	5.0	0	0
	8/18-20/09	37.5	32.9	0	0	0	0
Field 8	9/23-25/09	55.0	15.0	7.5	0	0	2.5
	9/30-10/2/09	22.8	15.0	2.5	2.5	2.6	0
Field 9	9/23-25/09	30.0	17.5	2.5	2.5	5.1	2.5
	9/30-10/2/09	7.8	5.0	0	2.5	0	0
Field 10	3/14-15/10	0	22.5	5.0	10.0	5.1	5.1
	3/22-24/10	0	30.0	0	7.5	0	0
Field 11	3/14-16/10	12.5	67.5	5.0	32.5	2.5	20.9
	3/22-24/10	2.5	76.9	0	27.5	2.6	23.2
Field 12	5/19-21/10	0	10.0	0	2.5	0	0
	5/26-28/10	0	20.0	0	0	2.5	0
Field 13	5/26-28/10	2.5	32.5	0	12.5	0	2.9
	6/2-4/10	0	41.0	0	7.5	0	0
Field 14	5/26-28/10	0	80.0	0	5.0	0	2.7
	6/2-4/10	5.0	65.0	0	5.0	2.6	0

[a]No in-crop survey and thus no index of abundance values due to harvest operations.

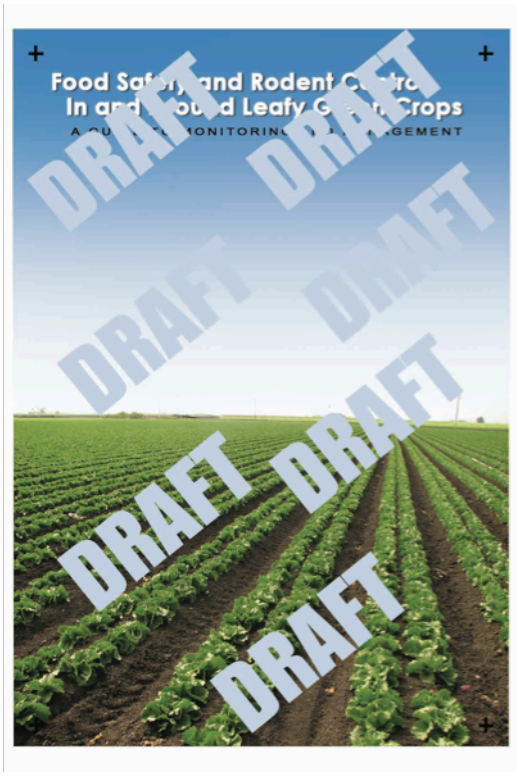
Table I. Changes in IA values from 1st to 2nd surveys for spinach and iceberg lettuce fields surveyed for rodents during the period from May 2009 through June 2010 in Monterey County, California.

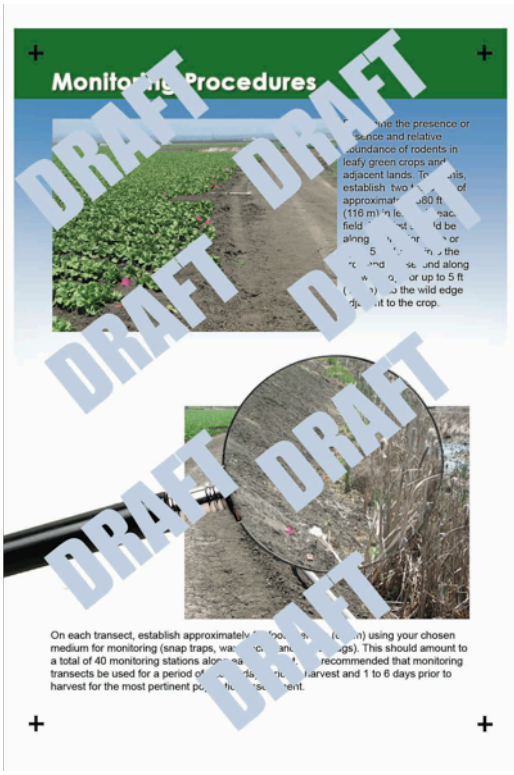
	Decrease		No change		Increase	
Item	In Crop	Edge	In Crop	Edge	In Crop	Edge
Wax block	6	2	3	1	4	11
Wax tag	4	6	8	4	1	4
Snap trap	4	5	4	4	5	5

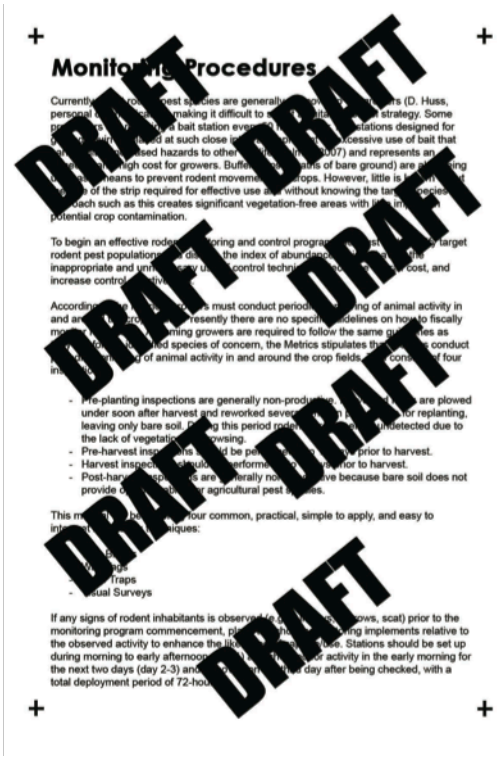
Table J. Location and number of wax blocks and wax tags fed upon by snails.

	Wax Blocks		Wax Tags	
Location	In Crop	Edge	In Crop	Edge
Field 1	0	22	0	0
Field 2	0	24	0	0
Field 3	0	9	0	0
Field 4	0	11	0	0
Field 5	0	49	0	6
Field 7	0	9	0	0
Field 8	0	14	0	0
Field 9	0	13	0	0
Field 12	0	27	0	1
Field 13	0	12	0	0
Field 14	0	16	0	0

Appendix 1. Excerpts from the draft field guide for rodents in leafy green crops.







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California Ground Squirrel
These animals live
Ground squirrels live
At 6 months of age young squirrels resemble adults.
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California Ground Squirrel
Ground squirrels
Legal
How do you manage
Traps
Fumigation
Toxic Baits
Notify public health officials
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Pocket Gopher
Mounds of fresh soil
Look for
Mole mounds
Also
DRAFT

Pocket Gopher
Damage
How do you manage
Traps
Avoid
DRAFT

Appendix 2. Example data sheet for wax block - snap trap survey.

Date _____

Ranch and field names_____
Crop_____

Wax Block		Snap Trap	
Crop	Wild edge	Crop	Wild edge
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			

Key for wax blocks: C = chewed, NC = not chewed, M = missing. Key for snap traps: 0 = no activity, S = sprung, M = missing.

If a mouse is caught, write down the species.

Appendix 3. Sample worksheet to calculate index of abundance values for snap traps and wax blocks.

Index of Abundance Worksheet

Ranch and field names_____ Crop_____

Sampling dates_____

	P	T	TN	S	S/2	TN-S/2	C	IA
Traps-in crop	2	20	40	0	0	40	0	(100 x 0)/40 = 0
Traps-edge	2	20	40	2	1	39	3	(100 x 3)/39 = 300/39 = 7.7
Wax block - in crop	2	20	40	0	0	40	5	(100 x 5)/40 = 500/40 = 12.5
Wax block -edge	2	20	40	1	0.5	39.5	15	(100 x 15)/39.5 = 1500/39.5 = 40.0

IA = 100 x C/(TN-S/2)

TN (trap or wax block nights) = P x T

Where

P = the number of sampling intervals
T = the number of traps or wax blocks for each interval
S = the number of traps missing, sprung with no catch, or the number of missing wax blocks.
C = number of mice captured or the number of wax blocks chewed on by rodents.