Characterizing and Averting Cottontail Rabbit Damage in a Southern California Nursery

Tracy Ellis, Autumn Sartain, Ryan Miller, Cheryl Wilen, and **Terrell Salmon**
University of California Cooperative Extension – San Diego County, San Diego, California

ABSTRACT: Cottontail rabbits are a serious problem in Southern California. Of particular concern is the damage they do to ornamental plant and tree nurseries. Rabbit browsing reduces plant quality, kills containerized plants, and damages irrigation systems. Although anticoagulant baiting for cottontail rabbits is legal in California, growers should also consider multiple integrated tactics for rabbit damage control. This project employed GPS mapping technology to locate the occurrence of rabbit damage and correlate it with irrigation type, container, planting density, canopy width, and canopy height. GPS was also used to monitor the impact of experimental strategies to reduce rabbit damage. Strategies to reduce rabbit damage included the use of protective covers on irrigation tubing, exclusionary fencing, and trapping. Radiotelemetry was used to confirm the location of suspected rabbit harborages within the nursery. GPS results indicate that 1.27 to 1.9-cm (½ to ¾-in)-diameter irrigation line covers were effective in reducing rabbit damage to the irrigation system. Exclusionary fencing using erosion-control silt fencing acted as an excellent temporary barrier to protect individual growing areas and groups of planting beds, but it was found to be impractical for many nursery situations. Rabbit catch rates increased when traps were used in conjunction with drift fences. General tactics recommended to container nurseries based on these study results include: protecting and modifying irrigation systems, use of exclusionary fencing, trapping in conjunction with drift fencing, and modifying known rabbit harborages where possible.

KEY WORDS: cottontail rabbits, damage, fences, GPS, horticulture, irrigation, plant protection, radiotelemetry, *Sylvilagus audubonii*, trapping

Proc. 22nd Vertebr. Pest Conf. (R. M. Timm and J. M. O'Brien, Eds.)
Published at Univ. of Calif., Davis. 2006. Pp. 522-526.

INTRODUCTION

The cottontail rabbit (*Sylvilagus audubonii*) has been identified by nursery growers as the primary cause of damage to irrigation systems and plants, causing economic loss to ornamental tree nurseries in southern California through vegetation destruction and chewing of drip irrigation lines. This damage can be recognized by characteristic 45°-angle cuts to the spaghetti irrigation tubing, similar to rabbit damage on browsed twigs (Orr 1940). One large commercial tree nursery in San Diego County reported more than $10,000 annually in costs due to plant loss, plus at least $12,000 for labor and materials to repair irrigation lines. Damage to plants from rabbit feeding and from water stress due to damaged irrigation lines has not been determined, but these are believed to be significant.

Cottontails in California are believed to have a life span of 12-15 months. They can have up to 6 litters per year, with a litter size of 3-4 offspring (Orr 1940, Chapman and Willner 1978, Chapman *et al*. 1982). In the western U.S., natural predators of cottontails are mountain lion, coyote, weasel, gray fox, badger, bobcat, raccoon, skunk, mink, kit fox, red-tailed hawk, Cooper's hawk, Swainson's hawk, golden eagle, great horned owl, gopher snake, and rattlesnakes (Storer 1933, Orr 1940, Chapman *et al*. 1982, Brown and Krausman 2003). The cottontail has evolved to survive the heat extremes of the southwest U.S., and it has a remarkable adaptability to feed on a variety of plants depending on seasonal availability (Orr 1940, Turkowski 1975, Chapman *et al*. 1982). Cottontails are known to regularly travel 30 m or more from cover (Hall 1951), have foraging areas with a diameter of 213 m (700 ft), and have been observed to travel 1,006 m (3,300 ft) from the point of capture (Fitch 1947). While one strategy to reduce damage from brush rabbits (*S. bachmani*) is to establish buffer zones of cleared space between natural areas and resources needing protection (Hall 1951), given the large distances that cottontails will venture from cover to find feed, it is unreasonable to expect such habitat modifications will effectively reduce cottontail damage.

Cottontail rabbits are legally classified as game animals, and surveys of game hunting licensees by the California Department of Fish and Game (CDFG) document rabbit take in several California counties (Lauridson 2004). Cottontail control with anticoagulant bait was conducted from the mid-1990s thru 2004 in Orange County California, but that use was temporarily discontinued pending a legal review. A recent opinion by the California Attorney General allows the use of anticoagulant bait to take cottontail rabbits that are causing damage to crops or property (Lockyer 2004). CDFG Code Section 4186 allows landowners or their agents to take cottontails when damage to crops or forage is observed.

Little is documented about the actual impact to nursery production caused by rabbit damage, or the types of growing practices that make a nursery crop most vulnerable to damage. There has been little research directed towards addressing the specific needs of container nursery production suffering rabbit damage. Experience has shown that damage by cottontail rabbits can be minimized by exclusion with 3-foot-tall fences (known as "rabbit-proof fences") secured tightly to the ground, allowing no means for rabbits to go under the fence (Storer 1933, Marsh *et al*. 1990, Salmon *et al*. 2006).

Although effective in a large nursery, fencing is expensive to install and maintain (Marsh 1985). Additionally, we observed that fencing interferes with the constant foot and machinery traffic that occurs during plant production. Fencing to prevent rabbit intrusion may be practical when the product has high monetary value and likelihood of damage (Marsh 1985).

One strategy to reduce the number of rabbits in the nursery may be habitat manipulation. Most studies on habitat manipulation focus on enhancing populations for harvest purposes (Chapman *et al*. 1982, Swihart and Yahner 1984, Van Vuren 1998, Mankin and Warner 1999). However, a nursery may be able to apply those lessons to manipulate rabbit habitat to reduce populations and damage.

To better understand the biology and ecology of rabbits in container nurseries, we studied rabbits in a commercial nursery to determine the characteristics of nursery production and their relationship to rabbit occurrence and damage. We tested methods to reduce damage to irrigation systems and exclude rabbits from crops. We also evaluated trapping strategies and made observations to determine rabbit habitat preference. The final objective was to define some feasible options that could be used by container nurseries for rabbit damage management.

METHODS AND RESULTS

A commercial wholesale container tree nursery located in northern San Diego County was used for these trials. The nursery uses cultural practices common to the nursery industry in southern California.

Mapping of Growing Practices and Relating It to Rabbit Irrigation Damage

We used Global Positioning System (GPS) mapping technology in combination with Geographic Information System (GIS) software to understand the relationship between nursery practices and the incidence of rabbit damage. To create the map of the nursery, we used a backpack-mounted Trimble Model Ag132 GPS device, in association with HGIS™ software (StarPal, Inc., Fort Collins, CO) and a handheld Trimble GeoExplorer3 in association with GPS Pathfinder Office™ software (Trimble Navigation Limited, Westminster, CO).

Nursery employees conducting irrigation repair recorded the location of rabbit damage with handheld GPS units on 24 dates approximately once weekly from December 2004 to September 2005. GPS devices given to nursery staff for damage waypoint collection were Garmin eTrex Legend™ GPS receivers used in association with DNR Garmin™ software (Minnesota Dept. of Natural Resources, St. Paul, MN). The GIS program used was ArcView™ 8.3 (Environmental Systems Research Institute, Redlands, CA). These irrigation damage waypoints were totaled for each bed and analyzed to relate the irrigation damage profile with characteristics of nursery production.

The 166 nursery beds at the nursery were characterized by irrigation type, container name, planting density, canopy width, and canopy height. Each bed was described in terms of characteristics of irrigation type (drip, hanging, hand-watered, or adapted drip), container name (1-gal, 5-gal, 15-gal, 24-in box, 36-in box, or 48-in box), planting density (low, medium, or high), width of canopy [within pot, 0.3-m (1-ft) overhanging, 0.6-m (2-ft) overhanging, 0.9-m (3-ft) overhanging, greater than 0.9-m (>3-ft) overhanging] and height of canopy [shorter than 0.9 m (3 ft), 0.9-1.8 m (3-6 ft), 1.8 - 3.6 m (6-12 ft), or above 3.6 m (>12 ft)]. Many of the beds were characterized as having mixed features (7 beds of mixed irrigation type, 32 beds with mixed containers, 13 beds with mixed densities, 52 beds of mixed canopy heights, and 63 beds with mixed canopy width). In the cases of mixed beds, the total waypoints were divided by the percentage of area associated with the characteristic in each bed. For example, if there were 15 total waypoints collected for a bed but the bed had 50% drip irrigation and 50% hand-watered, the data from the bed was entered twice (once for each variable), and there were 7.5 waypoints assigned to drip irrigation and 7.5 waypoints assigned to hand watering. As a consequence to dividing the beds into sections, there are more than 166 units used for each variable in the analysis (N in Tables 1-3). Using the GPS data, we identified production methods with strong vulnerabilities for rabbit damage. Irrigation systems that lay on the ground and within reach of rabbit gnawing had the greatest damage, while hanging irrigation and irrigation modified with wider tubing was less susceptible to rabbit damage (Table 1). Medium and high planting density, and beds with vegetation closest to the ground where the plant canopy provided cover, also tended to be associated with the most irrigation damage by rabbits (Table 2). Plants in containers less than 61 cm (24 in) in height were at greatest risk even when irrigation lines were lifted off the ground, as the rabbits jump onto 68-L (15-gal) containers of 46-cm (18-in) height to cause damage (Table 3). No features of tree canopy width and height were associated with rabbit damage.

Table 1. Damaged irrigation recorded by GPS, where rabbit damage characterized by 45°-angle cuts were observed in beds and sections of beds (N) having the irrigation type of either on-the-ground drip, hanging, hand watered, or drip lines protected with 1.9-cm (¾-in) covers.

Irrigation Type	N	Mean	SE
Drip	101	64.48	16.0
Hanging	39	5.78	3.1
Hand-watered	29	0.78	0.3
Protected Drip	4	1.50	0.3
Total	***170***		

Table 2. Damaged irrigation recorded by GPS, where rabbit damage characterized by 45°-angle cuts were observed in beds and sections of beds (N) having either low, medium, or high planting density.

Planting Density	N	Mean	SE
High	54	65.45	29.3
Medium	41	49.54	11.7
Low	85	15.38	3.8
Total	***180***		

Table 3. Damaged irrigation recorded by GPS, where rabbit damage characterized by 45°-angle cuts were observed in beds and sections of beds (N) having various types of nursery planting containers.

Container Name	N	Mean	SE
15 gal	43	96.91	36.4
24" box	56	26.21	7.2
36" box	55	17.88	4.2
5 gal	28	3.43	2.4
48" box	11	4.17	2.0
1 gal	10	3.43	2.4
Total	***198***		

Modification of Irrigation Line Covers

We found that most of the rabbit damage to irrigation was associated with drip irrigation using 0.64-cm (¼-in) spaghetti tubing and 68-L (15-gal) containers planted at high density. Beds with hanging drip lines or 1.9-cm (¾-in) tubing were seen to have less damage (Table 1). Therefore, two studies were conducted to evaluate irrigation line covers to protect the 0.64 cm (¼-in) diameter spaghetti tubing. The first study tested various types of covers 46 cm (18 in) in length and included PVC pipe, recycled black poly hose, clear vinyl tubing, vinyl hose, and duct tape. All types of covers reduced rabbit cutting of the tubing in comparison to the control. Covers using recycled 1.9-cm (¾-in)-diameter poly hose were easiest to install over the spaghetti tubing and may be the most economical, if they are reused. The second study used irrigation line covers 61 cm (24-in) in length, made of 1.9-cm (¾-in) diameter poly hose. We measured a 96% decrease in damage waypoints, from an initial 27 waypoints (March 28 and April 13, 2005) to 1 damage waypoint (May 1 to May 21, 2005).

Exclusion and Trapping

Black silt fence was evaluated as alternative exclusionary fence to the poultry fence normally recommended for rabbits. The advantage of this type of fence is its ease of installation and removal. The 76-cm (30-in)-height silt fencing is a black fabric cloth with built-in wooden posts at 4.6-m (15-ft) intervals, which may be purchased at most hardware stores for the purpose of erosion control. In an observational study, 274 m (300 ft) of silt fence, installed with supplemental posts and soil covering the bottom flap, was used to closely encircle a bed containing rabbit-damaged jasmine in 1-gal pots. No ill effects were observed due to the black plastic retaining heat or blocking airflow to the plants. The results of this demonstration plot indicate that silt fence was an excellent temporary exclusionary fence, preventing further rabbit damage. However, it should be recognized that exclusionary fencing is not practical in many situations, because it hinders normal nursery operations such as moving stock or getting equipment into the area.

As part of the experimental trapping program at the nursery, one strategy was to use the black silt fencing as a drift fence in conjunction with trapping. The fence was placed in natural areas adjacent to production areas in the nursery, because rabbits were suspected of living in the natural areas and traveling to the planting beds. Doorways 0.3 - 0.9 m (1-3 ft) wide in the drift fence were monitored with Trailmaster™ infrared trail monitors (Goodson and Associates Inc., Lenexa, KS) and night photography to confirm that rabbits were being conditioned to use the drift fence and doorways. Once the rabbits were conditioned to the fence, #110 conibear traps and squirrel live traps 48 × 15 × 15 cm (19 × 6 × 6 in) were set in the doorways, along the paths near the fence, and at paths at the end of the fence. The catch rates (number of rabbits caught/number of trap nights) were 11-13% for trapping in conjunction with the drift fence (Table 4). Where no fence was present to direct the rabbits into the trap, such as live traps set between containers in a growing bed, the trapping success was reduced to 3% (Table 4).

Telemetry

Using radiotelemetry (AVM Instrument Company, Colfax, CA; Sirtrack, New Zealand), we followed the movements of 14 radio-collared cottontail rabbits captured and collared from 8 general areas in nursery to determine typical hiding places within the nursery property. The rabbits were generally observed weekly between August and November 2005. Estimated rabbit movement from the point of capture to the point of relocation varied widely as shown by the standard deviation (Table 5), but the rabbits were estimated to travel an overall average of 57 m (186 ft) from where they were collared to where they were generally relocated. Rabbits hid in various locations in the nursery including the following: natural brush, wood and recycle piles, bougainvillea hedges, under storage pallets, in iceplant plantings on slopes, under trailer buildings, in drainage pipes, in nursery vegetation, under and between rocks, and in riverbed/riparian areas. The rabbits found many habitats at the nursery conducive to hiding.

DISCUSSION

Rabbits continue to be an economic burden to nursery growers in southern California. Given the biology of cottontails with their dietary adaptability, variable range of movement, and their need for cover close to food sources, the typical nursery environment provides cotton-

Table 4. Catch rates of rabbit trapping program.

Strategy	Trap Type	Trap Nights	Rabbits Caught	% Catch
Drift Fencing	Live trap in doorway	60	8	13.3
	Conibear trap in doorway	104	12	11.5
	Live trap at end of fence	68	8	11.8
	Live trap along fence	104	11	10.6
Within Bed	Live trap	2,045	65	3.2
	Total	***2,381***	***104***	***4.4***

Table 5. Estimated distance each rabbit moved from the point of capture to the point of re-location.

Collar Frequency	Obs. per Rabbit	Mean Distance (m)	Std Dev (m)
0	4	42.6	16.2
5	3	31.5	4.2
8	5	60	63.6
16	5	46.2	21.3
26	4	73.8	2.1
35	4	125.4	20.7
39	7	33.3	22.5
41	2	119.1	69.3
49	6	36	4.2
51	3	47.1	7.5
55	5	49.8	29.7
67	5	27.9	10.8
72	4	88.5	32.1
76	4	59.7	17.7
Mean	***4.3***	***55.8***	***36.9***

tails an optimal environment for high survivability and reproduction. In addition, nursery operations in southern California are in multi-use areas usually interspersed among residential neighborhoods, making some means of control such as use of firearms in conflict with city ordinances. Furthermore, nursery operations are usually limited to daylight operating hours, leaving the rabbits undisturbed during their most active crepuscular hours of dawn and dusk. Although our study nursery had natural and domestic cottontail predators (coyotes, weasels, hawks, cats, and dogs were observed), these predators appeared unable to control cottontail numbers, given the advantages for the cottontail in the nursery environment.

We recommended that the nursery make ongoing efforts, as materials and time permit, to protect their business from rabbit damage. The efforts should include fencing or tabling potted plants known to be at high risk for rabbit browsing. Silt fence represents a flexible and easy-to-install method of exclusionary fencing in addition to the traditional use of chicken wire/poultry netting for those plantings of high value or that sustain heavy damage. Hanging or lifting irrigation lines where possible, and using covers over the spaghetti tubes, are effective methods to reduce rabbit damage to irrigation. In addition, nurseries may consider encouraging irrigation tubing manufacturers to develop spaghetti tubing more resistant to rabbit gnawing.

Nurseries may want to consider an ongoing program to reduce rabbit harborages by using habitat modification where possible. It may be appropriate to target areas that unintentionally provide habitat to reduce suitability. Some measures to reduce influx and suitability may include fencing between natural areas/groves and the nursery; decreasing cover for the rabbits in runways; thinning border vegetation that provides cover, such as the hedges, to reduce hiding places; regularly moving debris piles, recycled wood piles, and storage pallets to reduce breeding and cover within the nursery; and rotating pallets of stock.

In the circumstances when trapping is desirable to remove rabbits from an area, the use of traps in runways created by drift fence will be the most effective method.

ACKNOWLEDGEMENTS

Funding was provided by California Department of Food and Agriculture, Vertebrate Pest Control Research Advisory Committee, Contract #04-0401. Special thanks to Pardee Tree Nursery for allowing us to conduct the studies on their property, assisting in data collection, and for making valuable contributions to the project. The project was conducted under the University of California Davis Animal Care and Use Protocol #11694.

LITERATURE CITED

BROWN, C. F., AND P. R. KRAUSMAN. 2003. Habitat characteristics of 3 Leporid species in southeastern Arizona. J. Wildl. Manage. 67(1):83-89.

CHAPMAN, J. A., J. G. HOCKMAN, AND W. R. EDWARDS. 1982. Cottontails, *Sylvilagus floridanus* and allies. Pp. 83-123 *in*: J. A. Chapman and G. A. Feldhamer (Eds.), Wild Mammals of North America: Biology, Management, and Economics. The Johns Hopkins University Press, Baltimore, MD.

CHAPMAN, J. A., AND G. R. WILLNER. 1978. *Sylvilagus audubonii*. Mammalian Species 106:1-4.

FITCH, H. S. 1947. Ecology of a cottontail rabbit population in central California. Calif. Fish and Game 33(3):159-184.

HALL, E. R. 1951. A Synopsis of the North American Lagomorpha. University of Kansas Publ., Museum of Nat. Hist. 5(10):119-202.

LAURIDSON, P. 2004. Rank of cottontail take by selected California county. Report of the 2004 Game Take Hunter Survey, California Dept. of Fish and Game, Wildlife Programs Branch, Sacramento, CA.

LOCKYER, B. 2004. Opinion of Bill Lockyer, Attorney General, and Susan Duncan Lee, Deputy Attorney General. Official Reports, Office of the Attorney General, State of California, No. 03-806.

MANKIN, P. C., AND R. E. WARNER. 1999. Responses of eastern cottontails to intensive row-crop farming. J. Mammal. 80(3):940-949.

MARSH, R. E. 1985. Competition of rodents and other small mammals with livestock in the United States. Pp. 485-508 (Ch. 29) *in*: S. M. Gaafar, W. E. Howard, and R. E. Marsh (Eds.), Parasites, Pests and Predators. Elsevier Science Publishers, Amsterdam.

MARSH, R. E., A. E. KOEHLER, AND T. P. SALMON. 1990. Exclusionary methods and materials to protect plants from pest mammals–a review. Proc. Vertebr. Pest Conf. 14:174-180.

ORR, R. T. 1940. The rabbits of California. Occ. Papers, Calif. Acad. Sci. 19:1-227.

SALMON, T. P, D. A. WHISSON, AND R. E. MARSH. 2006. Wildlife Pest Control around Gardens and Homes, 2nd Ed. University of California, Division of Agriculture and Natural Resources, Publ. 21385, Oakland, CA. 122 pp.

STORER, T. I. 1933. Control of injurious rodents in California. University of California, College of Agriculture and Agricultural Extension Service, Circular 79, Berkeley, CA. 66 pp.

SWIHART, R. K., AND R. H. YAHNER. 1984. Winter use of insular habitat patches by the eastern cottontail. Acta Theriol. 29(4):45-56.

TURKOWSKI, F. J. 1975. Dietary adaptability of the desert cottontail. J. Wildl. Manage. 39(4):748-756.

VAN VUREN, D. 1998. Manipulating habitat quality to manage vertebrate pests. Proc. Vertebr. Pest Conf. 18:383-390.