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Status and Management of Coyote Depredations in the Eastern United States

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Introduction

The populations of coyotes (*Canis latrans*) have increased dramatically in the eastern United States since the early 1900s (Hilton, 1978; Chambers, 1987; Hill et al., 1987; Witmer and Hayden 1992). The expansion of the coyote range into eastern North America has been summarized by Parker (1995) and characterized as two distinct geographical events: 1) the northern front moving across southern Ontario and the Great Lakes region and 2) the southern front colonizing the southeastern United States from Arkansas and Louisiana. These two fronts expanded throughout the northeastern and southeastern United States during the 1960s and 1970s, finally converging during the mid 1980s in the central Appalachian mountains of Virginia and West Virginia. Upon their arrival, eastern coyotes, like their western counterparts, began killing livestock. There has been concern that coyote depredations in the eastern United States could cause significant impacts on sheep and other livestock industries (Slate, 1987; Witmer and Hayden, 1992; Witmer et al., 1995). Other authors have suggested that coyote predation is an important contributing factor in the decline of the American sheep industry (Terrill, 1986; Hilton, 1992).

Coyote depredations on livestock in the eastern United States have been documented by several authors (Witmer and Hayden, 1992; Witmer et al., 1995; Tomsa and Forbes, 1989). The USDA National Agricultural Statistics Service (NASS) completed surveys of "Sheep and Goat Predator Loss" during the years

1990, 1994, and 1999. Similar surveys of "Cattle Predator Loss" were made in 1991, 1995, and 2000. These nationwide surveys were completed during the final phases of coyote range expansion in the eastern United States and as coyote depredations in the east began to increase. During the 1990s, the USDA APHIS Wildlife Services (WS) programs in Virginia, West Virginia, and Ohio initiated programs designed to assist producers experiencing livestock depredations by coyotes. The WS program documents livestock losses, requests for assistance, and management activities through its Management Information System (MIS). WS uses the MIS system to produce annual reports on coyote depredation management activities. The NASS surveys and WS reports have not been analyzed on a regional basis or in the context of the range expansion of the coyote in the eastern United States. This paper reviews these data and examines the effectiveness of WS programs aimed at managing coyote depredation on livestock in the eastern United States.

Materials and Methods

NASS Reports

The "Sheep and Goat Predator Loss" and "Cattle Predator Loss" NASS surveys for 1991, 1995, 2000 and 1992, 1996, and 2001, respectively, were analyzed to determine quantities and trends in coyote depredation on sheep and cattle in the eastern United States. These data were compared with national averages and within eastern U.S. sub-regions based on livestock production and range expansion by coyotes. To account for changes in livestock inventories between survey years, coyote depredation was expressed as percent loss of

inventory. NASS annual state sheep and cattle inventories corresponding to each predator loss survey were used to determine percent loss of inventory. NASS divides its survey results into three regions including the Mountain/Western region, Mid-west region, and Southern/Eastern region. The southern/eastern United States, as delineated by NASS, includes: Alabama, Georgia, Maryland, New Jersey, Rhode Island, Virginia, Connecticut, Kentucky, Massachusetts, New York, South Carolina, West Virginia, Delaware, Louisiana, Mississippi, North Carolina, Tennessee, Florida, Maine, New Hampshire, Pennsylvania, and Vermont.

For the purposes of this paper, the southern/eastern states defined by NASS were grouped to reflect major areas of livestock production. The majority of sheep production east of the Mississippi River is concentrated in New York, Pennsylvania, Virginia, West Virginia, and Ohio. Ohio is the top ranking state in sheep inventory numbers east of the Mississippi River. Additionally, Ohio, Virginia, and West Virginia have each had coyote depredation management programs during the 1990s. Coyote depredations on sheep in the remaining southern/eastern states were excluded from this analysis due to low inventories. Cattle depredations were calculated by dividing the southern/eastern states into three sub-regions: New England (Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island), Mid-Atlantic (New York, Pennsylvania, West Virginia, Virginia, New Jersey, Maryland, Delaware, North Carolina, South Carolina), and Southeast (Alabama, Georgia, Kentucky, Louisiana, Mississippi, Florida, Tennessee).

USDA APHIS Wildlife Services Reports

Wildlife Services annual tables were used to determine trends in requests by the public to provide technical assistance with coyote depredation problems. The number of coyotes removed annually by WS programs in the eastern United States was employed as an indicator of program field activities and coyote population growth. The number of technical assistance requests and the number of coyotes removed by WS in the southern/eastern states described above was reported for fiscal years (FY) 1991, 1995, and 2000.

During the 1990s, WS had Integrated Wildlife Damage Management (IWDM) programs (sometimes referred to as Integrated Pest Management or IPM) to assist livestock producers in managing coyote depredations in Virginia and West Virginia. IWDM is described in Chapter 1, pages 1-7 of the *Animal Damage Control Program Final Environmental Impact Statement* (USDA 1994). The Virginia WS IWDM program has provided service from 1990 to present and the West Virginia WS IWDM program from 1996 to present. In Ohio, WS has provided extension assistance (rather than technical assistance). These extension activities are coupled with an indemnity program administered by the Ohio Department of Agriculture. The WS programs in Virginia and West Virginia have produced annual reports for their respective state departments of agriculture summarizing program activities. These annual reports were used to determine the effectiveness of IWDM programs in managing livestock depredations in the East. Trends in the number of operations, producers requiring assistance, sheep depredations per operation, and cost effectiveness of these programs were investigated.

Results and Discussion

A review of existing literature documenting coyote depredations in the eastern United States over the past decade reveals a picture which is not unlike those problems historically faced by livestock producers throughout the West. Coyote depredations on sheep and cattle in the eastern United States have risen sharply over the past decade, and those

states which implemented IWDM programs have managed depredation in a cost-effective manner.

Sheep/Lamb Losses

Predation is the leading cause of sheep and lamb mortality. Coyote depredations account for 60.7% of the total sheep/lamb losses to predators (NASS 1999). Coyote depredation of sheep/lambs in New York, Pennsylvania, Virginia, West Virginia, and Ohio markedly increased between 1990 and 1999 (Fig. 1). Between 1990 and 1999, the percent inventory loss to coyote depredations of sheep/lambs in New York, Pennsylvania, Virginia, West Virginia, and Ohio nearly doubled, increasing from 0.53% of the inventory in 1990 to 0.97% of the inventory in 1999. In 1999, these losses were valued at \$404,948. Sheep/lamb losses in the remaining southern/eastern states were valued at \$205,496, amounting to a total sheep/lamb loss in the eastern United States of \$610,444. According to NASS (1991-2000) inventories of sheep and lambs in these eastern states declined during the 1990s. The sheep inventory in the New York, Pennsylvania, Virginia, West Virginia, Ohio region, declined 14% faster than the reduction in sheep numbers nationwide (50% vs. 36%).

Coyotes typically prey more heavily on lambs than adult sheep. Coyote

depredations on lambs were not uniformly distributed throughout New York, Pennsylvania, Virginia, West Virginia, and Ohio. New York and Pennsylvania were impacted the least with 0.1%, 0.6%, and 0.8% loss of the annual lamb crop during 1990, 1994, and 1999, respectively (Figure 2). In Virginia, West Virginia and Ohio, coyote depredations accounted for 1.5% to 1.9% loss of the annual lamb crop between 1990 and 1999. A number of factors could have contributed to the relatively greater severity of coyote depredation in these states. These factors include coyote population densities, relative lower abundance of natural prey, differences in flock size, terrain, and livestock management. During the 1990s, New York and Pennsylvania flock sizes were typically smaller (2% to 25%) than flocks in Ohio, West Virginia, and Virginia. In Pennsylvania, it has been noted anecdotally that large flocks appear to suffer more coyote depredations than smaller, more intensively managed flocks (J. Suckow, USDA-APHIS-WS, personal communication). It is quite typical in Virginia and West Virginia to graze sheep on semi-isolated mountain pastures without human or animal guardians. Regardless, coyote depredations on lambs in New York and Pennsylvania have increased 88% between 1990 and 1999. This is a four-fold increase compared to the 21% increase in lamb losses in Virginia, West Virginia, and Ohio during the same

Figure 1. Sheep/lamb inventory and percent inventory lost to coyote depredations in New York, Pennsylvania, Virginia, West Virginia, and Ohio.

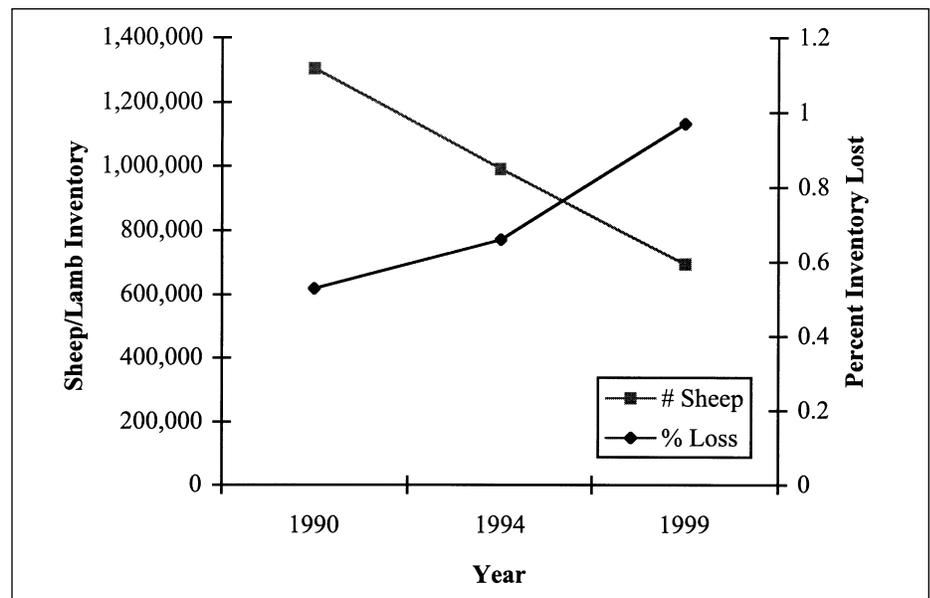
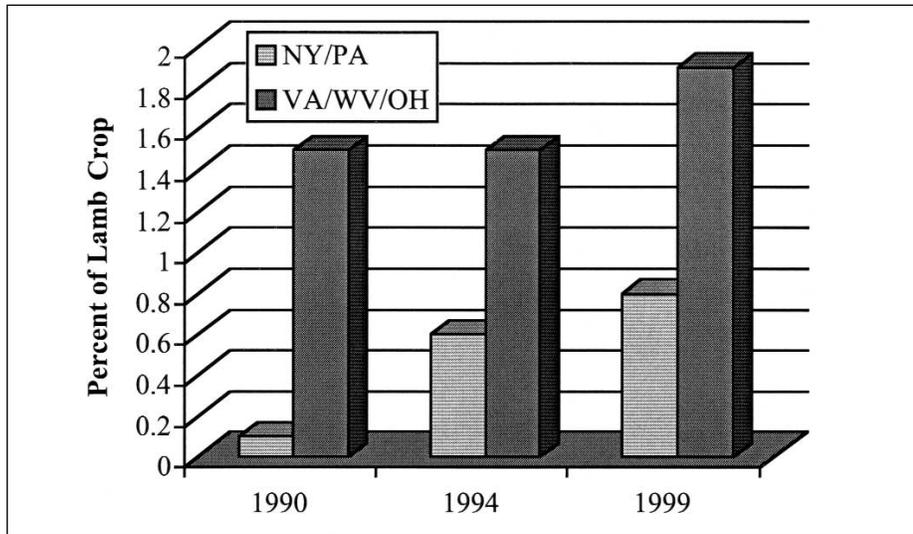


Figure 2. Percent of lamb crop killed by coyotes in New York and Pennsylvania compared to Virginia, West Virginia, and Ohio.



period (Fig. 2). This greater rate of loss is the motivation behind current attempts to establish an IWDM program in Pennsylvania (J. Suckow, USDA-APHIS-WS, personal communication).

Cattle/Calf Losses

Cattle losses to coyotes are generally restricted to calves during the first several months of life. Occasionally, adult cows also are killed when movements are restricted (e.g., when giving birth). Nonetheless, NASS (1999) estimates that coyotes account for 70.1% of cattle losses to predation. The inventory of cattle and calves in the eastern United States remained steady during the 1990s (Fig. 3). During this period, however, there was an overall rise in both the number of cattle/calves killed by coyotes and the percent of the inventory those depredations represent in the eastern United States (Fig. 3, Fig. 4). Between 1991 and 2000, the percent inventory loss of cattle/calves in the southern/eastern United States increased from 0.05% in 1991 to 0.11% in 2000. In 2000, these losses were valued at \$10,101,000.

The increase in coyote depredations on cattle in the eastern United States correlates with coyote range expansion and population growth during the past 20 years. The southern front of coyote range expansion swept across the southeastern states during the 1960s (Parker, 1995). This front then expanded further north and east through Tennessee and Kentucky during the 1970s and 1980s. Finally, during the late 1980s and early

1990s, coyotes colonized Virginia, West Virginia and the Carolinas. Coastal areas in the mid-Atlantic region have only recently seen large numbers of coyotes. Once established, coyote populations have increased. For example, coyote harvest data in Mississippi, increased from 1,200 in 1980 to 40,000 in 1989 (Bourne, 1991). Harvest of coyotes by hunters and trappers in Pennsylvania and Virginia suggests exponential growth in coyote populations in these states during the 1980s and 1990s (Witmer and Hayden, 1992; Wright et al., 1999). These increases in coyote populations correlate with the increase in cattle/calf depredation reported by NASS. By 1991, cattle/calf depredations by coy-

otes in the southeast United States were already equivalent to the national average (Figure 4). These losses continued to increase dramatically during the 1990s, exceeding the national average by 2000. In the mid-Atlantic region, cattle/calf depredation increased from almost immeasurable numbers to equal the national average between 1991 and 2000, reflecting the increase of coyote populations in this sub-region during the 1990s. Cattle/calf losses in the New England states were minimal.

Within the mid-Atlantic region, the relationship among coyote range expansion, coyote population growth, and cattle depredation is further illustrated. As coyote numbers increased within central Appalachia, coyote depredations increased three-fold (Fig. 5). Measurable levels of coyote depredations on cattle/calves in the Carolinas were not detected until the NASS survey in 2000 and the coastal states of New Jersey, Maryland and Delaware have yet to experience noticeably increased levels of coyote depredation (Figure 5). There are anecdotal reports in the western United States that coyote depredation on cattle is increasing as sheep numbers decline (sheep being relatively preferred prey); the Utah WS program recorded a 700-percent increase in requests for protection from cattle producers between 1998 and 2001 (M. Bodenchuk, USDA-APHIS-WS, personal communication). Evaluation of depredation by coyotes on cattle in the

Figure 3. Cattle/calf inventory and percent inventory lost to coyote depredations in the southern/eastern United States.

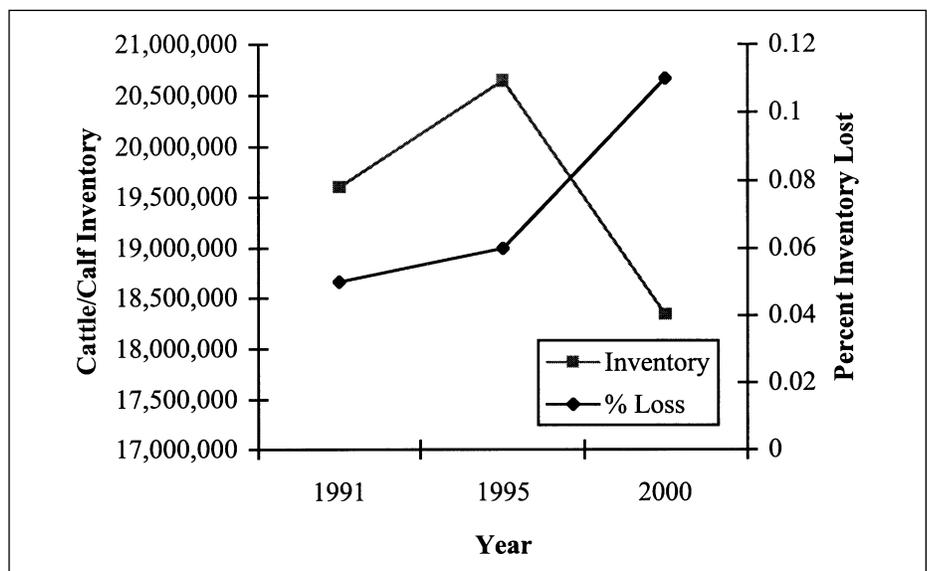


Figure 4. Number of cattle/calves killed by coyotes in the New England, Mid-Atlantic, and Southeast sub-regions of the eastern United States.

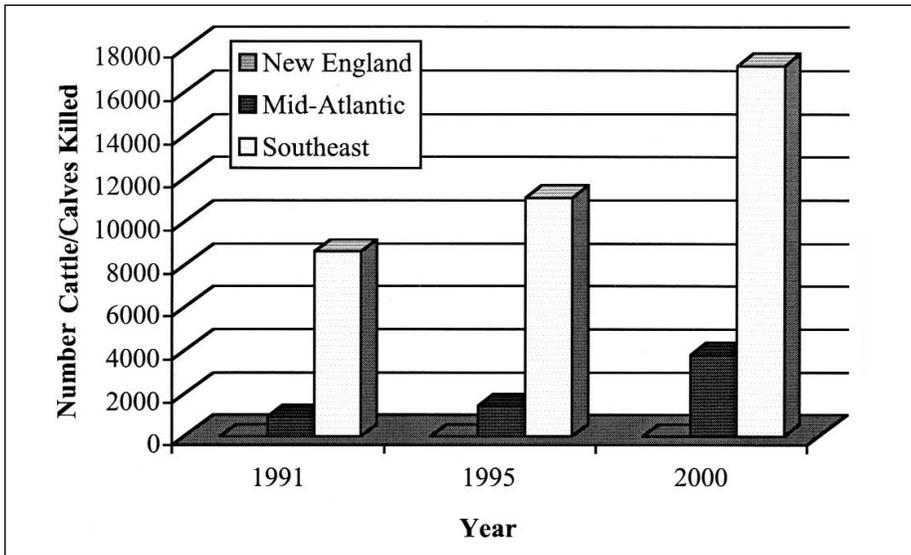


Figure 5. Number of cattle/calves killed by coyotes within the Mid-Atlantic sub-region.

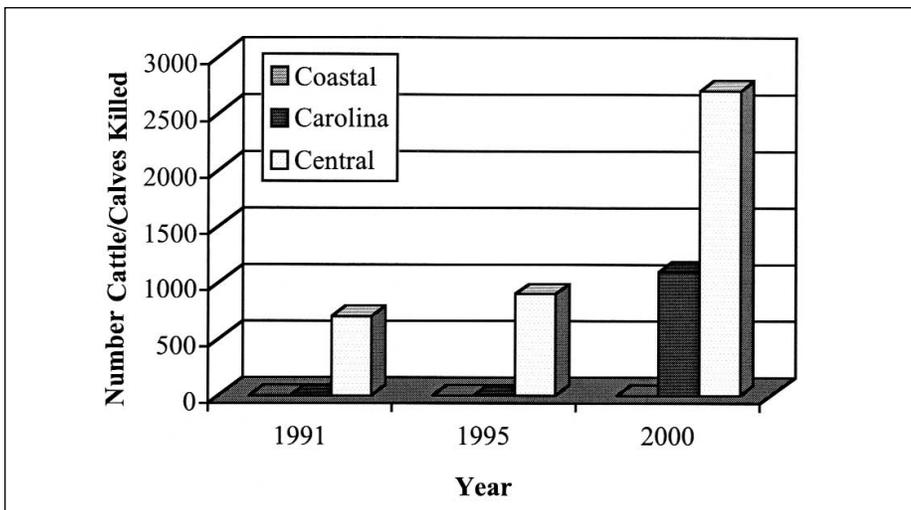
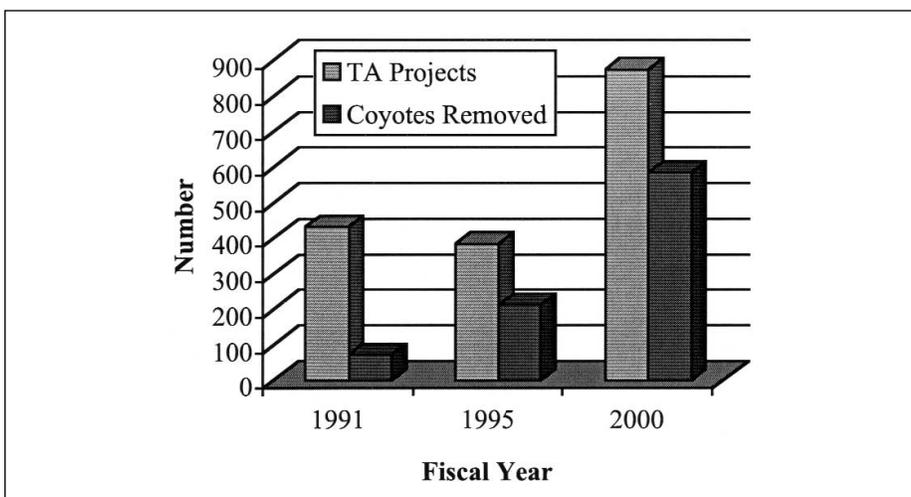


Figure 6. Technical assistance requests and number of coyotes removed by WS in the eastern United States.



eastern United States is complicated by the possibility the eastern coyote has developed behavioral and morphological modifications that enhance its ability to successfully prey on larger animals (Parker, 1995).

The impact of coyotes on livestock in the eastern United States is also reflected in the number of requests for assistance WS Eastern Region receives annually from the public. The number of technical assistance projects and the number of coyotes removed by WS Eastern Region programs increased during the 1990s (Fig. 6). During 2000, WS Eastern Region programs received 874 requests from the public for technical assistance over coyote damage. The number of coyotes removed by WS Eastern Region programs increased from 72 in 1991 to 585 in 2000. This increased take of coyotes is reflective of both increased program field efforts and increases in coyote populations in the East. These two parameters further illustrate the increasing concern by the public over coyote depredations and need for assistance.

Integrated Predation Management Programs

IWDM programs were established in Virginia and West Virginia to protect sheep, goats, and cattle in 1990 and 1996, respectively. These programs, administered by WS, involve the implementation of non-lethal (e.g., improved husbandry practices, predator resistant fencing, predator frightening devices, livestock guarding animals) and lethal (e.g., calling and shooting, traps, snares, M-44s, livestock protection collars) management techniques. Up to 14% (range 1.1% to 14.2%) of the sheep producers in these states use WS IWDM programs each year (Table 1). The number (percent) of sheep producers availing themselves of the WS program is somewhat dependent on the ability of the program to respond. In Virginia, between 1990 and 1997, approximately 1.5 employees were funded to provide service. This level of staffing was able to provide assistance to 1.1% to 2.0% of the sheep producers. The number of sheep producers utilizing the IWDM program increased (4.8% to 7.5%) in Virginia after 1998 as the number of Wildlife Specialists increased to 2.5 to

Table 1. Number of sheep operations receiving assistance from the WS IWDM programs in Virginia and West Virginia, 1990-2002.

Year	VIRGINIA			WEST VIRGINIA		
	Number of Sheep Operations*	Number Producers Assisted (%)	Number WS Specialists	Number of Sheep Operations*	Number Producers Assisted (%)	Number WS Specialists
1990	2,500	44 (1.8)	1.0	2,000	—	—
1991	2,400	50 (2.1)	1.0	1,900	—	—
1992	2,200	35 (1.6)	1.0	1,800	—	—
1993	2,100	24 (1.1)	1.0	1,700	—	—
1994	2,000	41 (2.1)	1.0	1,500	—	—
1995	1,900	28 (1.5)	1.5	1,600	—	—
1996	1,900	56 (2.9)	1.5	1,400	40 (2.9)	3.0
1997	1,800	49 (2.7)	2.0	1,300	56 (4.3)	3.0
1998	1,500	72 (4.8)	2.5	1,100	85 (7.7)	3.0
1999	1,300	84 (6.5)	2.5	1,000	104 (10.4)	3.5
2000	1,300	67 (5.2)	3.5	1,000	110 (11.0)	3.5
2001	1,400	83 (5.9)	3.5	1,000	142 (14.2)	4.0
2002	1,500	113 (7.5)	3.5	1,100	124 (11.3)	4.0

*Source: National Agricultural Statistics Service state livestock inventories for Virginia and West Virginia, 1990-2002.

3.5 employees. A similar pattern occurred in the West Virginia IWDM program. Sheep producers receiving assistance from the West Virginia IWDM program increased from 2.9% to 14.2% as the number of Wildlife Specialists increased. These numbers likely reflect both the ability of WS to respond to demand for service and the growing need for coyote depredation management.

Both Virginia and West Virginia

WS programs have reduced the number of sheep lost per producer on farms receiving IWDM services (Table 2). The number of sheep lost per farm is lower than would be expected if predation management programs were not in place. The rate of predator losses in the absence of a predation management program ranged from 1.4% to 8.1% for adult sheep and from 6.3% to 29.3% for lambs in several studies (Table 3). Based on the NASS (1999) report, predation losses

averaged 1.6% of adult sheep and 6.0% of the calculated lamb crop when a blend of non-lethal and lethal control strategies were used.

Savings attributed to WS IWDM programs to protect sheep in Virginia and West Virginia can be calculated using the NASS (1999) predation loss survey and state sheep inventory data (Table 4). The Virginia and West Virginia WS expenditure for predator damage management to protect sheep in FY

Table 2. Average number of sheep killed by coyotes per sheep producer receiving assistance from the Virginia and West Virginia IWDM programs, 1990-2002.

Year	VIRGINIA			WEST VIRGINIA		
	Sheep Killed	Producers Assisted	Sheep Killed/Farm	Sheep Killed	Producers Assisted	Sheep Killed/Farm
1990	555	44	12.6	—	—	—
1991	569	50	11.4	—	—	—
1992	623	35	17.8	—	—	—
1993	404	24	16.8	—	—	—
1994	363	41	8.8	—	—	—
1995	191	28	6.8	1,111*	40*	27.8
1996	402	56	7.2	101	40	2.5
1997	250	49	5.1	240	56	4.3
1998	229	72	3.2	460	85	5.4
1999	448	84	5.3	385	104	3.7
2000	337	67	5.0	288	110	2.7
2001	187	83	2.3	490	142	3.5
2002	234	113	2.1	129	124	1.0

* Represents the number of livestock producers contacted from April through September, 1996, and their reports of livestock lost for predations in the twelve months prior to April, 1996, before WS initiated predation management.

Table 3. Predator losses in the absence of a predation management program.

Source	Location	Year	Sheep lost %	Lambs lost %
Henne (1977)	Montana	1974	8.4	29.3
Munoz (1977)	Montana	1975	3.7	24.4
McAdoo and Klebenow (1978)	California	1976	1.4	6.3
Delorenzo and Howard (1976)	New Mexico	1974	not reported	12.1
Delorenzo and Howard (1976)	New Mexico	1975	not reported	15.6

Table 4. Savings attributed to USDA-APHIS-Wildlife Services (WS) predation management programs in Virginia and West Virginia, calculated from statistics compiled by the National Agricultural Statistics Services (1999).

Sheep and lambs	NASS Inventory	NASS Actual losses with WS program (%)	NASS Projected losses without WS program (%)	Difference	Average 1999 \$ value/head	Total saved
VA Sheep	65,000	400 (0.6)	3,705 (5.7)	3,305		\$ 274,315
VA Lambs	50,000	1,500 (3.0)	8,750 (17.5)	7,250		601,750
WV Sheep	40,000	300 (0.7)	2,280 (5.7)	1,980	\$83	164,340
WV Lambs	36,000	1,800 (5.0)	6,300 (17.5)	4,500		373,500
TOTAL	191,000	4,000	21,035	17,035		\$1,413,905

1999 was \$532,000. The total benefit (\$1,413,905) of these programs would indicate a 2.66:1 benefit cost ratio. This benefit is conservative, since the cost savings do not include projected losses to cattle and goats. Both Virginia and West Virginia provide assistance to cattle and goat operations, which were not included in this analysis. The marketing of the animals saved as a result of predation management benefits many segments of the rural economy, and not just individuals involved in direct production. Jahnke et al. (1987) reported a three-fold economic multiplier effect for the benefits of predation management in Wyoming. If this multiplier is applied to the total value of sheep saved in Virginia and West Virginia, then the value of predation management to businesses not involved in direct agricultural production would be \$4,241,715. The gross total benefit to all segments of the Virginia and West Virginia economy would be \$5,655,620.

Conclusions

NASS surveys of sheep and cattle predator loss during the 1990s and WS program records provide insight into the impact of coyotes on livestock in the eastern United States. Earlier concerns that coyote depredations in the eastern United States would increase and have an economically meaningful impact on sheep and other livestock industries

(Slate, 1987; Witmer and Hayden, 1992; Witmer et al., 1995) were well-founded. Coyote depredations on livestock increased significantly between 1990 and 2000. In Virginia and West Virginia, coyote depredations on sheep increased to the point that IWDM programs have been established to manage damage. The available evidence suggests that these programs are both efficient and economical for the producers served. In Ohio, New York, Pennsylvania, North Carolina, and South Carolina both sheep and cattle losses to coyotes appear to be reaching levels that will justify the creation of IWDM programs. The increase in coyote depredations on cattle in the mid-Atlantic region may be related to decreasing sheep inventories and increasing coyote populations as appears to be the case in some western states. Cattle losses to coyotes in the southeastern United States have exceeded the national average. These trends are likely to continue in the future. Coyote depredation on livestock in the eastern United States may eventually become a problem for producers on par with losses traditionally experienced by producers in the western United States.

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