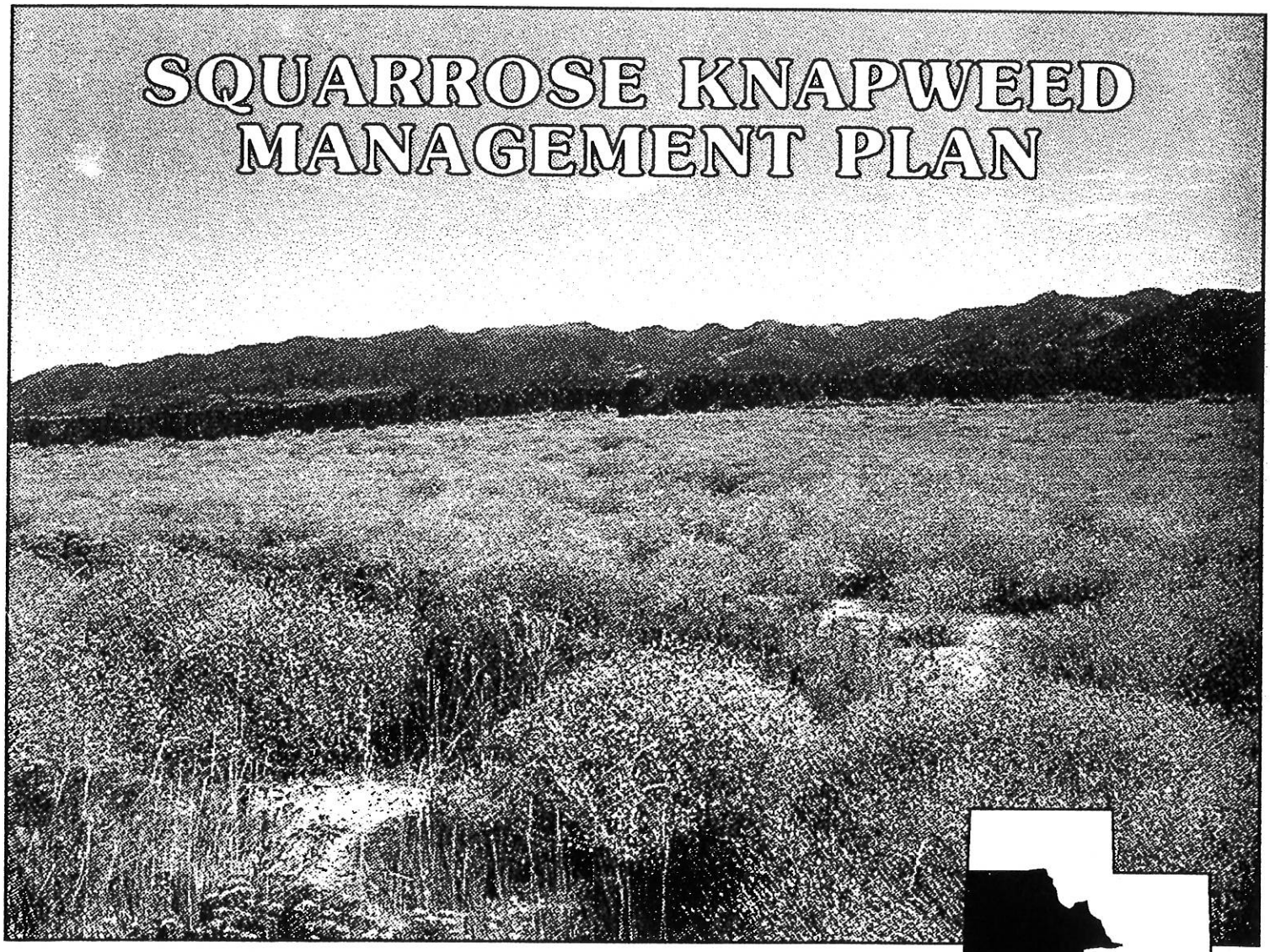
Utah Cooperative Weed Management Demonstration Area



March 1996

UTAH COOPERATIVE WEED MANAGEMENT DEMONSTRATION AREA

SQUARROSE KNAPWEED MANAGEMENT PLAN

MARCH, 1996

Planning Team

The following list shows the members of the Utah Squarrose Knapweed Committee that were selected to prepare this plan. However, the plan was also reviewed and has had input from all of the other partners involved on the committee.

Team Leader:	Pat Fosse, Bureau of Land Management
Team Members:	Jeff Banks, Utah State University Extension Educator for Juab County
	Jody Gale,Utah State University Extension Educator for Millard County
	Craig Searle, Utah County Weed Supervisor
	Brent Bunderson, Utah State University Extension Educator for Tooele County
	Darrell Cook, Utah Dept. of Agriculture
	Stephen Burningham, Utah Dept. of Agriculture
	Dea Nelson, US Forest Service
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	Lowell Decker, Bureau of Land Management
	Bob Garrett, Juab County Weed Supervisor

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I. Issue

The invasion of squarrose knapweed (*Centaurea virgata* Lam. ssp. *squarrosa* Gugl) in west central Utah is like a **raging** biological wildfire. This weed is a very aggressive competitor, which readily invades disturbed areas and then spreads into adjoining undisturbed areas, slowly replacing native perennial vegetation. The long-term impact of this weed invasion is loss of vegetative biodiversity which effects wildlife, livestock, water quantity and quality, soil, production capability and marketability of cropland, recreational and wilderness opportunities and aesthetic value. The magnitude of this infestation is such that if drastic and large scale efforts are not implemented immediately, this weed will be uncontrollable. The west desert ecosystem of Utah is prime habitat for squarrose knapweed. This ecosystem is approximately 15 million acres.

II. Background and Purpose

Squarrose knapweed is a very aggressive and highly competitive rangeland weed native to the eastern Mediterranean area. It is a long-lived taprooted perennial. It differs from the other *Centaurea* species that have invaded the western United States, in that the seed heads are highly deciduous. This characteristic allows the seeds of this plant to spread easily by livestock, wildlife, and on vehicles, both on and off road. Squarrose knapweed is also more adaptable than the other knapweed species. It can thrive in a wide variety of precipitation zones, soil types, and elevations.

Concerns about squarrose knapweed in Utah were first raised in the early 1950's. Documentation from 1954 indicates that the infested area was contained within one township just west of Tintic Junction, near Eureka, Utah. Several alternatives to address this infestation were discussed at a special meeting on squarrose knapweed held in Nephi on November 3, 1954. The group, which included many of the same partners as the current effort, made the decision to complete research on this weed and in the meantime, try to keep it from spreading (see attachment 1). The research identified by this group was completed during 1955, 1956, and 1957. A publication written by Delmar C. Tingey from Utah State University was released in 1960 showing the results of the research (see attachment 2). No documentation of discussion or control work was found for the period from 1960 through 1981. Documentation from a 1981 meeting indicates that estimates of infested acreage were then in the "hundreds of acres." In 1982, another meeting was held. At the 1982 meeting, the decision was made that each county would survey the infested acreage and would declare squarrose knapweed a county noxious weed. The counties involved (Tooele, Juab and Utah) declared the weed as noxious in 1982. Since then, independent control efforts by each county have been conducted on an annual basis. However, these efforts were limited and inconsistent due to small county budgets and perceived higher weed priorities within the counties. During 1986 a Squarrose Knapweed Control Plan was prepared by the Fillmore Office of the Bureau of Land Management (BLM) which outlined goals, objectives, and planned actions to manage and/or control this weed. A relatively significant budget was appropriated to the Richfield District BLM for weed control during 1987, 1988 and 1989. Aerial spraying, as well as ground spraying was conducted during this period and the first biological control agents were released in this area. Between 3,000 and 5,000 acres were treated with herbicides during 1987 and 1989.

Squarrose knapweed was added to the Utah Noxious Weed list in December, 1987. From 1990 through 1994, the counties continued some control efforts with limited involvement from the BLM due to budget constraints. The control efforts were beginning to be coordinated through the Tri-County Weed Committee formed in 1993. Through this forum, annual tours were organized during 1993, 1994 and 1995. County commissioners, congressional delegates, the landowners and land managing agencies of the affected lands and the general public were invited to the meeting. The tours helped bring attention to this problem. Because of the efforts of the committee members, the tours, the Utah Weed Control Association, and agency personnel BLM obtained funding in 1995 to address this growing weed problem.

During 1995 a comprehensive weed inventory was completed within the Weed Management Area (WMA) by Juab County and BLM through an Assistance Agreement. The Utah Department of Agriculture also contributed to this effort and the other counties involved were in support of this effort. This inventory was completed using a Global Positioning System (GPS) unit, so the information could be easily shared and used by the many partners. Quality data was gathered through this inventory effort and the maps produced as a result of this inventory have been an invaluable resource in planning management strategies contained in this plan. Suppression, control, prevention and education efforts were also coordinated and enhanced during 1995. Approximately 1,000 acres of knapweed were treated in high priority areas during 1995. High priority areas were small, new populations of squarrose knapweed along the infestation frontier or perimeter, as well as road right of ways, livestock trails and recreation areas that were contributing to the fast and far reaching spread of seed.

The 1995 inventory data indicates that there are approximately 21,000 acres infested by squarrose knapweed in west central Utah. Some areas have not been mapped as thoroughly as others. A breakdown of the current data is shown in Table 1 as percentages of the total infestation.

Table 1. Land Status of Infested Area

Counties	BLM	Private	USFS	State School	Other	Total by County
Juab	29.7	46.4	0	1.3	10.1	87.5
Utah	0.4	3.3	0	0.1	0	3.8
Tooele	4.2	1	0	0.4	0.5	6.1
Millard	2.2	0	0	0.1	0	2.3
San Pete	0	0.3	0	0	0	0.3
Percent by Ownership	36.5	51	0	1.9	10.6	100

Research has shown that many of the knapweed species have an allelopathic relationship with other plants (Rick Kelsey, Knapweed Symposium 1989). An allelopathic plant is one that releases chemicals having the ability to prevent or retard growth and/or seed germination of neighboring plants. There has been no specific research on squarrose knapweed, but infestation patterns seem to indicate that squarrose knapweed has this allelopathic characteristic. This characteristic, and perhaps more importantly, the ability of squarrose knapweed to compete for resources and readily spread seed, allows it to become established and then grow into large monocultures. This weed is spreading rapidly.

This weed has significantly reduced the carrying capacity of rangelands and crop production of farmlands. One of the first effects of squarrose knapweed invasion is the loss of native perennial plants. In the long-term, squarrose knapweed impacts wildlife habitat by competing with and eventually replacing native vegetation. Loss of plant diversity reduces the "health of the ecosystem" and has direct impacts on many resources. Reduced plant biodiversity directly impacts animal diversity by reducing habitat and food. Watersheds are directly impacted by increased soil erosion, which in turn affects water quantity and quality. Recreation and wilderness opportunities are impacted on a limited basis in the heavily infested areas. The aesthetic values are adversely impacted in infested areas.

During fiscal year 1996, the Squarrose Knapweed Cooperative Control effort was selected as one of the four demonstration weed management areas within BLM and $120,000 was appropriated to BLM (Richfield District, Fillmore Resource Area and Salt Lake District, Pony Express Resource Area) for this project. Demonstration weed management areas are intended to highlight what can be accomplished through cooperative efforts and partnerships and will be used to document successes and failures in order to provide guidance in the development of other weed management areas. A Memorandum of Understanding was developed between the partners (see attachment 3), in which each partner agreed to work together within their own jurisdiction and resources to achieve a more effective and efficient control program than anyone would obtain singly. This plan is prepared in order to coordinate management efforts primarily towards squarrose knapweed control, but also includes other noxious or new and invading weeds within the designated management area. It also defines the most efficient and effective strategy and use of our combined resources in the management of noxious weeds.

III. Partners

Bureau of Land Management: Richfield and Salt Lake Districts Forest Service: Wasatch-Cache, Fishlake, Uinta & Manti-LaSal Forests
Utah Department of Transportation (UDOT)
US Fish and Wildlife Service (USFWS)
Utah State University Extension
Utah Weed Control Association (UWCA)
Juab County
Tooele County
Utah County
Millard County

Eureka City
Vernon City
Union Pacific Railroad (UP)
Dugway Proving Ground
Utah State and Institutional Trust Lands Administration
Utah Department of Agriculture (UDA)
Utah Division of Wildlife Resources (UDWR)
Utah Farm Bureau
Animal and Plant Health Inspection Service (APHIS)
Agricultural Research Service (ARS)
Natural Resource Conservation Service (NRCS)
Farm Services Agency Incorporated (FSA)
Tintic School District
Private Landowners

IV. Goals and Overview

The overall goal of this plan is to cooperatively manage the squarrose knapweed infestation on approximately 150,000 acres in west central Utah. (See attachment 4 map for boundaries of the WMA.) Management strategies will include preventing new infestations and reducing current infested acreage and/or populations by using strategies from fire fighting technology rather than traditional weed management strategies.

This management plan is directed primarily towards squarrose knapweed, but whenever any other noxious weeds are observed within the WMA, they will be mapped and managed along with the squarrose knapweed. Other known noxious weeds within the WMA include: Scotch thistle, purple loosestrife, Dyer's woad, white top (hoary cress), perennial pepperweed, spotted knapweed, Russian knapweed, and field bindweed.

This plan will cover a period of 10 years, but will be reviewed annually by all partners to make adjustments due to gained knowledge and experience, progress or lack thereof, and fluctuating budgets of the partners involved. An annual progress report will be prepared and a formal evaluation of progress towards meeting objectives will be completed during the fifth year of the project (2000).

Innovative weed control strategies emulating wildfire fighting methodology will be used in this effort. This strategy was first outlined by Dr. Steven Dewey, Extension Weed Specialist Utah State University, in 1995 (see attachment 5). This strategy includes:

Prevention
Detection
Suppression (Control)
- Rapid Response
- Size-Up
- Containment/Confinement
- Mop-up

Revegetation/Rehabilitation

Integrated weed management practices including biological, mechanical and cultural control options will be employed in addition to herbicide application.

Biological control will be the long-term strategy for suppressing large dense populations in the main body of the infestation that are not currently designated as high priority or critical areas. Herbicide application will be the primary method used to eradicate perimeter populations, small isolated spot infestations, and populations in other areas designated as high priority for containment or eradication.

The long-term goal is to reduce the infestation, both population and acreage, to a level where biological control along with proper management practices will keep the weed in check.

V. Objectives and Planned Actions

A. Prevention

1. Stop the spread of squarrose knapweed.

a. Apply herbicides to existing infestations along all road ways, livestock trails, developed recreational sites, and areas that receive concentrated recreational use within the main body of the infestation in an attempt to keep seed from spreading. All road rights-of-ways within the WMA will be considered high priority. Other high priority areas for treatment include: Yuba Recreation Area, Little Sahara Recreation Area, Cherry Creek Motorcycle Race starting and ending points, Simpson Springs Campground, livestock trails, Jericho shearing grounds, Dog Cemetery at Lookout Pass, Beckstrom Corral, Lofgren and Benmore road areas, Mona Reservoir, Fish Springs Wildlife Refuge, Eureka City, and Elberta Slant Road Area. The dyer's woad infestation within and near the Tintic Pastures will also be considered as high priority for treatment because the infestation is small enough that rapid eradication is an attainable goal.

b. Apply herbicides to all known small isolated patches or individual plants along the perimeter of the infestation (spot fires) with the goal of eradicating these small populations and preventing further seed source and spread. New, relatively small populations are known to exist in Sanpete and Wasatch Counties and are suspected in other surrounding counties. Known or discovered infestations outside the boundaries of the Squarrose Knapweed WMA will also receive high priority for herbicide application. This will be accomplished through coordination with county personnel in the surrounding counties, including White Pine County, Nevada. This coordination will be completed through extension agents and weed boards, as well as BLM.

Check on Dyers Woad ownership at Kendall property and Mona area

c. Require Fire Management Officers, contractors and fire crews to wash or clean all equipment between fires, whenever possible, especially heavy equipment used to cut firelines.

d. Avoid staging fire suppression equipment and resources in weedy areas.

BLM

e. Inspect gravel pits for noxious weeds prior to issuing permits for sand and/or gravel removal.

f. Seed all areas in which the soil surface is disturbed with certified seed (State Seed Laboratory tested) appropriate for the area. Add stipulations to permits in all programs making the respective user groups accountable for controlling weed infestations caused by their actions. For example, if a right-of-way holder or grantee (such as utility corridors) creates soil disturbance which allows noxious weeds to become established or spread, they must be accountable to eradicate the infestation.

Larry

g. For mineral related activity, retain bonds for weed control of any noxious weeds within the reclamation area(s).

h. Rehabilitate all burned areas unless sufficient perennial grasses exist in the understory prior to the fire to protect the watershed and prevent encroachment by undesirable plants. Surveyors and fire rehabilitation contractors should clean all equipment when moving from one project to another. This will be added as a stipulation to all contracts for fire rehabilitation work.

Larry

Knappweed Tour

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Weed Tour

i. Encourage all user groups to use only certified weed free feeds (hay, grain, pellets, and bedding) on public lands and make them accountable for weed infestations resulting from their actions, whenever possible. The goal of the committee is to have BLM adopt a requirements similar to that of the Forest Service requirements that only certified weed free feeds be allowed on public land. Whenever possible, encourage user groups to feed only weed free feeds for at least 96 hours prior to bringing their animals into an uninfested area. Horses and pack animals should be groomed and tack cleaned to remove weed seeds when moving from a weedy area to an uninfested area.

- Invite Governor -

2. Education and awareness directed towards user groups, legislators, other programs within agencies, schools and the general public.

Larry - Daryl - Don -

a. Hold an annual squarrose knapweed tour during the full flower stage of squarrose knapweed. Invite all partners, user groups, the governor of Utah, legislators, and the general public.

b. Develop educational materials for youth as well as adults describing the benefits of weed prevention and management and the negative impacts that

weeds cause to our environment. Emphasis will be placed on how weeds spread and how to prevent the spread of weed seeds. As a minimum, a slide show and display (for county fairs, etc.) will be developed. - Jim show

c. Provide schools with educational materials and educate school children about weeds, as opportunities arise. Work with faculties to get appropriate materials in school curriculum.

d. Educate agency and county personnel, in all programs, in the identification of noxious and new and invading weeds and weed prevention measures. For example, county road crews, fire fighters, BLM Realty Specialists, Minerals specialists, Oil and Gas specialists, Outdoor Recreation Planners, Archaeologists, etc.

e. Study and share information on using early spring livestock grazing as a tool in reducing weed populations, seed production and vigor.

f. Set up an ATV washing or air blowing station at Little Sahara during at least one holiday weekend each year to raise awareness of the problem and of prevention measures. Labor Day weekend would probably be most effective because the current year's seed would be ripe.

g. Install informational signs at Little Sahara and Yuba Reservoir Recreation Areas encouraging people to help prevent the spread of noxious weeds.

h. Distribute weed educational materials (pamphlets, posters, etc.) at Little Sahara and Yuba Recreation Areas, to user groups, and to affected cities.

i. Work with Utah Division of Wildlife Resources (UDWR) to educate hunters about the impacts of weeds on wildlife habitat, the benefits of prevention and early suppression, and how they can help stop the spread. This could be done through hunting proclamations and gun safety classes.

j. Educate organized recreational groups about the impacts of noxious weeds, the benefits of prevention and suppression and how to help stop the spread.

k. Further educate livestock operators about the impacts of noxious weeds, the benefits of prevention and suppression and what they can do to help prevent the spread. This will be done at organized events such as Cattlemen and Woolgrowers meetings. We will identify the herds that are travelling through the main infested area and track which Forest Service and BLM allotments, as well as which private land is subjected to seed carried by these sheep. This information will be shared so that all affected landowners and/or land management agencies can watch for new infestations in these areas. We will meet with these specific sheep operators to raise their awareness of the problem and implement some

simple, logical, management changes to prevent the spread of seed.

BLM Mineral People

l. Educate miners about the impacts of noxious weeds, the benefits of prevention and suppression and what they can do to prevent the spread.

County

m. Work with City governments to further educate them about the impacts of noxious weeds, the benefits of prevention and suppression and what they can do to help prevent the spread. Provide educational materials to Chambers of Commerce.

n. Work with private landowners to further educate them about the impacts of noxious weeds, the benefits of prevention and suppression, the best methods to prevent the spread and control or if possible eradicate specific weeds, and programs that may be available to help them financially with weed control projects. The NRCS, FSA and the counties will take the lead on working with private landowners.

o. Recognize outstanding cooperators in weed control and management each year. Award these outstanding cooperators with plaques and media coverage. The recognition ceremony will be part of the annual tour.

Gordon Young

B. Detection

Jim Show

1. Inventory

a. Use GPS units and appropriate software (GIS, Arc Info, other) to keep current inventory updated as much as possible. If the GPS unit is not available, mark any additional information on 7½ minute topography maps to be digitized. If, after four years, the updated information is not inclusive or adequate to measure progress or plan strategies, then another large scale inventory operation will be planned for the fifth year (2000).

b. Educate others in the identification of noxious weeds and ask their assistance in detection. (Planned actions in education and awareness are covered above).

C. Suppression (Confine, Contain, Control, Mop Up)

1. Herbicide Application: The purpose of herbicide application is to eradicate populations in high priority areas. We will start on the perimeter or infestation frontier and move closer and closer to the main infestation from all directions as these smaller, outer populations are eradicated. Our objective is to reduce the squarrose knapweed infestation to 15% of the 1995 level (population) within 10 years (2005). This objective may be adjusted if gained experience and knowledge warrant a need for adjustment. During the first few years of the project, we do not expect large acreages of squarrose knapweed to be treated with herbicides because we will concentrate on the small dispersed populations. This strategy of

herbicide treatment will also result in a seemingly high cost per acre, but the long-term results will be much more effective. As we move from the outside of the infestation inward, each year the number of acres treated will be greater and the cost per acre less. Our objective for 1996 is to treat approximately 4,000 acres of squarrose knapweed. This will be a baseline and a minimum number of acres to be treated each year. As we progress in the plan we will have more knowledge and experience in projecting the number of acres to be treated on an annual basis. This will be determined each year during the annual review meeting. Individuals applying herbicides will be required to strictly follow all labels and application directions, as well as all applicable state and federal laws.

a. Use the herbicide mix determined to be most efficient for each situation. Currently, the herbicide mix that has been determined to be most effective in the control of squarrose knapweed in rangeland situations is 0.25 lbs. active ingredient/acre to 0.375 lbs. active ingredient /acre picloram and one lb. active ingredient/acre (4 lb. active ingredient/gallon formulation) 2,4-D (Dr. Steven A. Dewey, 1994). This mixture should be used in rangeland situations whenever practical, unless ongoing research determines a more effective solution.

b. Priority areas for herbicide application are identified above under Prevention. These areas will be treated each year until we are satisfied that the population has been eradicated. The road ways and recreation areas will be checked and if necessary, treated every year for the foreseeable future.

c. Priority areas for herbicide application may be added or changed as gained information, knowledge and experience indicate a need. This will be an agenda item each year at the annual review meeting.

d. Areas within the main body of the infestation that are not categorized as high priority areas may be treated with herbicide as beneficial opportunities arise. For example, areas burned in wildfires and reseeded may be treated to keep the knapweed from becoming re-established. This will be determined by the team on an annual basis.

e. Monitor treated areas each year and retreat if necessary to prevent further seed production. This will be done until the seed source in the soil is completely exhausted for each area.

f. As populations around the perimeter are eradicated, high priority control areas will be "moved in" accordingly, so that the polygon of infestation becomes smaller and smaller from every direction. The perimeter high priority control areas will be adjusted each year by keeping the inventory updated and using it as a tool in planning our annual strategy.

g. The method(s) for herbicide application (aerial, truck, ATV, backpack) will be determined for each priority area on an annual basis. The

agency(s) or individual(s) responsible to complete the application and accountable for the funding will be determined for each priority area annually.

2. Biological Control

a. We will continue to support research into biological control. Research will be done on both new and existing control agents to determine the most cost effective agents or combination of agents. Current funding from BLM towards biological control research and releases is $13,000. This also includes two to three other weed species state wide. Our goal is to maintain, as a minimum, this level of funding.

b. Work with Utah State University (USU), Agricultural Research Service (ARS), APHIS and possibly local groups such as schools, cities or private landowners, to establish one to several insectaries within the main body of the infestation within the next few years. The number of insectaries would depend on funding appropriated for this effort.

c. Work with USU, ARS and APHIS to increase the number of release sites, so that eventually all areas within the main body of the infestation will be impacted by some type of biological agent.

3. Cultural Methods of Control

a. On agricultural land or land once used for agricultural purposes within the main body of the infestation, encourage and promote deep tillage for a minimum of three consecutive years and then reseeding with competitive perennial plants for rangeland use or competitive crops such as alfalfa. Research has shown that tilling to 6" or less does not effectively kill squarrose knapweed, tilling to 8" will kill most of the squarrose knapweed, and tilling to 10" will kill all of the mature squarrose knapweed plants (D.C. Tingey 1960). Tillage should be done in the spring prior to seed ripe and again in the late fall after seeds have germinated. Appropriate seed mix prescriptions to return any areas to rangeland will be provided by the ARS (Howard Horton 797-3079) or this committee upon request. All equipment used to till the land should be cleaned before it is moved from the tilled infested areas.

b. Preliminary indications are that early spring livestock grazing reduces the competitiveness and vigor of knapweed (B.E. Olson & J.R. Lacey, 1994 and Harvey Gates, personal observation, 1995). Scientific studies will be set up during the spring of 1996 to help determine if this is the

case. If it is, this information will be shared with all livestock operators in the area and we will use every opportunity to design grazing systems and changes in season of use to accommodate intense grazing during the time when squarrose knapweed is most susceptible to grazing and desirable perennial vegetation is not. As knowledge is gained, it will be shared with all partners.

c. Encourage all user groups to dig up single plants or very small infestations if found along the infestation frontier **and** report any infestations to the county weed supervisor or any member of this committee.

D. Rehabilitation

1. Emergency Fire Rehabilitation

a. All areas where wildfires occur that do not have adequate perennial understory vegetation to prevent noxious weeds from becoming established and dominating the site, should be reseeded with an appropriate certified seed mixture during the fall following the fire. BLM and Forest Service already do this as standard operating procedure. This should also be done on state and private land, when possible. Appropriate seed mix prescriptions can be obtained from the ARS (Howard Horton) or this committee upon request.

2. Rehabilitation of other disturbed areas

a. All areas within the WMA which incur soil surface disturbance should be seeded with an appropriate certified seed mix during the fall following the disturbance.

3. Revegetation of areas following herbicide application.

a. Treated areas in which the majority of the plant composition consists of squarrose knapweed should be reseeded with an appropriate certified seed mix during the fall following treatment to protect the watershed and prevent the weed from becoming re-established. A seed mixture of two to several grasses should be used, since grass is the only vegetative component that is tolerant to the residual effects of the herbicides effective in controlling squarrose knapweed. The ARS has done considerable research in this field (Howard Horton, personal comment, 1996). They have the most expertise in Utah on which seed mix, application method, and timing of application will work best for each given soil type,

precipitation zone and elevation. Howard Horton or Kay Asay of the ARS in Logan have offered their assistance, upon request, to anyone planning rehabilitation work within the WMA.

4. Management practices following revegetation.

a. All areas that are reseeded for any of the above mentioned reasons will be rested from livestock grazing for a minimum of two grazing seasons to allow the desired plant seedlings to become established.

b. Proper range management practices will be employed in revegetated areas, so as not to overgraze desirable plants and allow noxious weeds the opportunity to become reestablished.

c. All preventative measures discussed in this document will be strictly adhered to in areas that have been revegetated to avoid reinfestation.

d. Revegetated areas will be monitored closely for reinfestation of noxious weeds. Any new noxious weeds will be eradicated immediately by herbicide application.

VI. Research Needs

A. In order to maximize efficiency in eradication of small patches of squarrose knapweed, we need to know the maximum time that the seeds remain viable. Research conducted on this species from 1955 to 1957 indicated that the seed remained viable for only three years (D.C. Tingey, 1960). We would like to be certain of this so that areas that are treated with herbicide and checked and mopped up for three consecutive years without seed production can be considered eradicated. We will help fund this research through USU.

B. Continuing research is needed in the use of new and existing biological agents as discussed above.

C. Continuing research is needed in the use of herbicide solutions to determine which solution is most cost effective. The Chemical Companies, specifically Dow-Elanco, has offered to set up study plots for this purpose.

D. Research is needed into the use of different kinds of livestock (sheep, goats, cattle) and seasons of use to determine how to best use livestock grazing as a tool in the management of squarrose knapweed. Preliminary studies are being established by BLM during the spring of 1996. We will explore other research opportunities and existing data from other states on spotted knapweed to obtain this information. We will also ask the

BLM State Office to complete a literature search for any research that has been done for knapweed in general and squarrose knapweed specifically.

E. Research is needed on the effect of fires on squarrose knapweed. BLM plans to establish transects during the spring of 1996 in an area burned in a wild fire during the summer of 1995 (Death Creek fire). One transect will be established in an area that was reseeded during the fall of 1995 and another in an area that was not reseeded.

VII. Resources, Budget and Estimated Costs

A. Resources

1. The partners in this effort have agreed to share resources within their jurisdiction in order to accomplish our overall goals. We are hopeful that funding levels will at least be maintained, but they **are** subject to change due to congressional priorities and changes in administration. Priorities will be determined each year during the January annual review meeting based on available funding and knowledge gained from the previous year. The following lists the resources that each partner can contribute to this project at this time:

BLM: $120,000, several work months, truck with spray unit, two ATV's with sprayers, back pack sprayers, some personnel along with other duties (these work months will be funded from the benefitting activity such as range, wildlife, recreation, etc ...).

Juab County: $15,000, Norstar computerized spray truck, two people season long, two pick-up trucks with spray units.

Tooele County: $4,000, Norstar computerized spray truck, one person, a significant stockpile of herbicide (600 gallons 2,4-D)

Millard County: $2,000, one pick-up truck with spray unit, one person, back pack sprayers.

Utah County: $6,000, two people, one pick-up truck with spray units, one Norstar computerized spray truck. Two trailer sprayer units available for private landowners.

The other partners will contribute labor, time, dollars or resources to attain the overall goals and objectives within their respective jurisdictional areas. The amount contributed will depend on the number of infested acres occurring within their respective jurisdictional areas.

B. Estimated Costs

During 1995, the cost per acre to treat squarrose knapweed was $32. Since we plan to use the same strategy during 1996, it is expected to cost about the same amount per acre. Table 2 shows estimated costs to complete the first year of the plan. This is subject to change on an annual basis as gained knowledge and experience indicate the need. This is only a general guideline to follow for the first year of the plan. Budget, costs, and accountability will be submitted each year as part of our annual operating plan. Costs will be tracked by each partner and will be submitted as part of our annual report.

Table 2. Estimate Costs for 1996

Prevention		
Education (brochures, videos, educational materials, etc)	$ 1,000	
Awareness (annual tour, wash stations, signs, awards, media coverage, etc.)	$ 7,000	
Subtotal		$ 8,000
Detection (update inventory, mapping, GPS unit)	$ 10,000	
Subtotal		$ 10,000
Control		
[1] Herbicide treatment @ $32/acre on 4,000 acres.	$128,000	
Maintenance of spray equipment	$ 2,500	
Personal Protective Equipment	$ 1,500	
Biological - insectaries, insects to increase releases.	$ 8,000	
Subtotal		$140,000
Rehabilitation - 300 acres @ $30/acre for seed and application	$ 9,000	
Subtotal		$ 9,000
Research and Monitoring		
Biological research	$ 10,000	
Grazing practice research	$ 5,000	
Plant physiology research	$ 5,000	
Herbicide research	$ 5,000	
Monitoring (equipment, film processing, etc.)	$ 1,000	
Subtotal		$ 26,000
TOTAL ESTIMATED COST FOR 1996		$193,000

[1] The cost per acre will be reduced each year as we move inward and get into larger and denser stands or squarrose knapweed. Spot treatment of small perimeter infestations is very labor intensive, thus accounting for the high cost per acre.

VIII. Measuring Progress, Monitoring, Evaluation and Reporting

A. Monitoring

1. Permanent photo plots will be established in several different areas including: areas with dense populations (monocultures of squarrose knapweed), roadways with linear infestations, areas ¼, ½, 1 and 2 miles from the established biological release sites, areas with small patches planned for eradication, areas where the infestation has started but are not yet monocultures of squarrose knapweed, uninfested areas near the infestation and susceptible to spread of the weed. Some photo plots have been established in past years and will continue to be photographed. Each site may not be photographed each year, but will be photographed at least every three years. Photo plot areas will be assigned to specific partners so that the area is covered in the most efficient manner.

2. Frequency transects and size class plots will be established by BLM in an area that has had consistent early spring grazing by sheep and an adjacent area that has no livestock grazing. Additional test pastures may be set up to determine the results of different kinds of livestock, intensities of use, and seasons of use on squarrose knapweed.

3. Frequency transects will be set up by BLM in an area that was infested with a dense stand of squarrose knapweed, burned in a wildfire during 1995 and reseeded during the fall of 1995. Comparison transects will also be set up on adjacent private land that burned in the same wildfire and was not reseeded.

4. Transects measuring frequency or some other parameter may be established in high priority areas along with photo plots if it is determined by the team that this data is needed to measure progress. We will coordinate with APHIS to set up monitoring studies to measure the effectiveness of biological control agents.

5. Range cages may be placed along with photo plots or transects to be used as an additional tool to measure effectiveness of specific treatments or strategies.

6. Comparison Inventory - Since we have a quality baseline inventory of squarrose knapweed within the WMA, progress will be measured by using comparison inventories from subsequent years. Our goal is to keep the inventory current by updating the data using GPS units or mapping and inputting the data as new populations are discovered or as inventoried populations are eradicated.

7. We will explore the possibility of using remote sensing (land sat images) to measure progress.

B. Evaluation

Data will be summarized and analyzed on an annual basis. This data will be shared at our annual review meeting and included in our annual report. A formal

evaluation of progress towards meeting our goals and objectives will be prepared during the fifth year of the plan (2000). All scientific data will be summarized, analyzed and recommendations will be prepared to enhance progress towards meeting our ecological goals and objectives.

C. Reporting

A report will be prepared each year by February 15 for submission to the Washington Office, BLM as well as to all of the partners in this effort. This report will include a narrative of all accomplishments, successes, failures and knowledge gained from the previous year. It will include a summary and analysis of the data gathered, including photographs. All herbicide application records will be compiled and included in this report. It will also have a summary and breakdown of all costs associated with this project. This will be categorized as costs associated with each of our goals (prevention, detection, control, and rehabilitation). Costs will be listed for each partner, as well as a total project cost. We will attempt to show benefits along with the costs, although the first few years of the project many of these benefits will be hard to define or will be intangible benefits, such as greater public awareness and knowledge.

IX. Summary

We have a large and diverse group of very talented, very committed people working on this project and we are optimistic that we will attain our goals and objectives within the ten year time frame **if** we can obtain a somewhat consistent budget. We intend to be a pioneer in weed management using innovative, new approaches mirroring current fire fighting techniques and carefully documenting our gained knowledge and successes so that other groups can emulate our processes and successes. The "**health of the land**" is at stake and we know this "**biological wildfire**" can be managed and brought into balance with our native vegetative communities. We are doing this for our children and grandchildren and we do not intend to let them down.

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Minutes Of A Special Meeting On Squarros Knapweed
Held At Nephi, Utah November 3, 1954 at 1:15 p.m.

Those in Attendance were:

Carl Frischknecht, Director Utah Extension Service, Logan
Ernest O. Biggs, Tooele County Agent, Tooele
Jm. R. Judd, Tooele County Assessor
Ross Gowans, Tooele County Commissioner
Ted Robertson, Land Owner, Spanish Fork (5th North & 2nd East)
Dick Robertson, Land Owner, Spanish Fork
Hal L. Michelsen, Juab County Weed Committee
B. R. Ellison, Weed & Seed Supervisor, State Dept. of Agriculture, Salt Lake
J. Pratt Allred, Bureau of Land Management
J. A. Pomenke, Bureau of Land Management
C. Wayne Cook, Range Management Department, U.S.A.C., Logan
Louis A. Jensen, Extension Agronomist, U.S.A.C., Logan
D. C. Tingey, Agronomy Department, U.S.A.C., Logan
Bliss H. Crandall, Assistant Director, Utah Agricultural Exp. Station
Rodney G. Rickenbach, Millard County Agent, Fillmore
Blaine Robinson, Millard County Weed Supervisor, Hinckley
Ralph H. Horne, Assistant, Millard County Agent, Delta
Haton Sakey, Lehi
F. M. Anderson, Weed Supervisor, Utah County
S. R. Boswell, Utah County Agent, Provo
Elmer D. Taylor, District Agricultural Inspector, Provo
C. R. Lomax, Commissioner, Juab County
H. R. Francom, Commissioner, Juab County
W. L. Hoyt, District Judge, Nephi
E. Alton Elbertson, Officer Manager, ASC Mona
Ariel Jorgenson, Commissioner, State Department of Agriculture
Ray Burtenshaw, Juab County Agent Nephi

The meeting was called to order by Dr. Carl Frischknecht who stated the purpose of the meeting and reviewed briefly what had been done on the problem up to now. He mentioned the previous meeting held here on September 23, and the assignments that were made as follows:

1. Get a positive identification of the weed.
2. Learn as much as possible about the history of it.
3. Hold meetings with weed committees of surrounding counties to acquaint them with it and organize surveys.
4. Visit seed plants to acquaint them with it and ask cooperation in preventing its spread.
5. Formulate plans for research on its habits and possible control methods.
6. Meet again here early in November to hear reports and decide what action to take.

Ariel Jorgensen then took charge of the meeting and served as chairman. Louis Jensen was appointed secretary and was instructed to take minutes. Mr. Jorgensen made some introductory remarks calling for cooperation of everyone concerned with this problem.

Bliss Crandall related how the weed had been reported in May, 1954, and specimens collected by Ray Burtenshaw and Louis Jensen for identification. It was first thought that it was Spotted Knapweed (Centaurea Maculosa). Later when better specimens were obtained a positive identification was made by Arthur Holmgren, Curator of the Intermountain Herbarium and Arthur Chronquist of the New York Botanical Gardens. The weed was identified as Squarros Knapweed (Centaurea Squarrosa). These taxonomists state that it comes from the Middle East and they have no previous record of it in North America.

A report was presented by Bernard Ellison of the work he and Louis Jensen had done as assigned in the September meeting. Together they met with county weed committees of Tooele, Utah and Millard Counties. Plant and seed samples of the weed were shown to these groups and the problem explained. Each county agreed to make a survey to determine if this weed is present in the county and meet in November to make a report. Ellison and Jensen also visited the seed plants in Salt Lake and Delta to acquaint them with the problem and ask their cooperation in helping to prevent its spread in commercial seed.

S. R. Boswell introduced F. M. Anderson, Utah County Weed Supervisor and Dick Robertson, owner of some of the infested land. They reported making a survey of the sheep bed grounds on the desert winter range and also the area where sheep are unloaded at Soldier Summit for the summer range, and also the roads in each vicinity. In the past few years, the sheep have ranged on the infested area just prior to being moved to these areas. None of the weed was found in any of these places.

Ariel Jorgensen reported that Squarros Knapweed had been officially declared noxious recently by the State Board of Agriculture.

Louis Jensen reported on investigations as to the possible history of this weed in the state. A Mr. Morgan, employee of the McIntrye Ranch was shown a specimen of the weed and claimed that he had seen it near the grain elevators when he had first come to work for them in 1928. A Mr. Mortensen, an employee of the Moody Bros. Seed Company in Delta claimed that he saw it in 1938.

Mr. Robertson reported that the infested area had been used for an emergency landing field as late as 1950. The railroad has been there about 50 years.

Dr. Wayne Cook reported on the survey of the infested area by him and his assistants from the Agricultural College. This was needed to determine the extent of the problem and to see what research is needed. A general reconnaissance survey was made with men traversing the area on lines 1/8 mile apart. He passed out maps with the infestations marked and explained them as follows: They found a dense stand on the area of the wheat field not plowed this year, and a much less dense stand on the part plowed this summer. It was found on the road out to Tintic Junction and on U.S. Highway 36, going west 4½ to 5 miles out from the elevators. It goes out on the road toward Eureka and on Highway 6, to just north of the Mammoth Filling Station.

It was found on the railroad only about 3/4 mile in each direction from the elevators. There is a spotted infestation on the range land north of Highway 36. Main infestation is south of Highway 36. The infested area would take in a little more than one township or about 10,000 acres. It appears that livestock and vehicles have spread it. It isn't likely to go out on desert ranges because growth is made late. We need not be too alarmed about it on the range. However, it is of concern in crop seed. It apparently will compete with, but not crowd out, native vegetation on foothill ranges. It is relatively unpalatable, but livestock will utilize it where they are forced to do, due to a lack of anything better. The plants are difficult to distinguish from ditch aster and wild lettuce.

Reports of county surveys were made as follows: Juab County - Ray Burtenshaw. Their survey agrees with that of Wayne Cook's except they found it all the way to Eureka and a little beyond.

Tooele County - Ernest Biggs. Reports were received of it in two locations, but investigation of these proved them false. The only place they found it was about two miles inside the Tooele County line on Highway 36.

Millard County - Rodney Rickenbach. Considerable time had been spent driving in a car and making spot checks, but none was found.

Utah County - S. R. Boswell. None found except on edge of county north of Eureka.

Dr. Carl Frischknecht asked the group to discuss now what should be done including educational work. Ariel Jorgensen stated that he felt we should inform those who operate in the area such as the stockmen, etc.

Rodney Rickenbach posed the question: Just how serious is the problem? Some discussion of this followed.

Bernard Ellison stated that the seed trade doesn't seem to be worried about the adverse publicity it might bring.

Ariel Jorgensen reminded the group that we need to take a practical approach to the problem. The land owners have the first responsibility.

D. C. Tingey was asked to tell about the characteristics of the weed and what methods are recommended for its control. He stated that we know it is a deep-rooted and probably long-lived perennial. Burs or seed heads are carried and are believed to be the main means of propagation. As to control methods, we do not know yet but it is believed that it can be controlled fairly easily on crop land by clean cultivation for two years. There is a question as to practical methods of control on range land. The spraying done this year with 2,4-D prevented seeding but as yet it isn't known what success was obtained in killing the roots.

The proposed research is: Study the plant and its habits. Study the need as to germination and length of time it will remain viable.

Trials on determining the effect of tillage including deep tillage and regular clean cultivation; The effect of the different chemicals at different stages of growth, rate and kind; The actual cost to clean the weed up by different methods; Study re-seeding or how to replace the present weedy vegetation with more desirable vegetation.

Ariel Jorgensen again asked for recommendations as to what should be done and considerable discussion followed.

Bernard Ellison stated that it is still too soon to decide on a quarantine. We need research on practical methods of control.

D. C. Tingey pointed out that this problem emphasizes the need for a rather complete weed survey in the state. The question is, how much of a problem is this weed likely to be?

One of the Juab County Commissioners stated that they did not want to spend public money on control until we have determined the best methods and can have an effective program. Let's conduct our research before we go out on a large scale program.

Blain Robinson said he would like to see the main area quarantined to keep livestock out. A discussion followed as to a practical way to control livestock.

Judge Hoyt stated that he thought we should consider eradication now, before it spreads further.

Dr. Wayne Cook asked to express his own personal opinion and recommended the following: Be practical and allow research to precede any drastic measures. For the present, follow a program of supression and prevention of seed production by plowing the tillable land, spray roads and railroads. A committee should be appointed to work out details. The group should meet again next summer or fall to appraise the accomplishments and plan a program for the next year.

Motion by S. R. Boswell and seconded by Dick Robertson that a committee be appointed for this purpose. Motion carried. Each agency agreed to appoint a representative to this committee.

Ariel Jorgensen was appointed chairman of this committee and agreed to call the group together in the near future to work out some recommendations.

Meeting adjourned at 4:30 p.m.

Minutes taken by Louis Jensen

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DECEMBER 1960

The author: Delmar C. Tingey is professor of agronomy and in charge of weed control research. Lois Cox, assistant Experiment Station publications editor, assisted in the preparation of the manuscript.

Cover picture: Squarrose knapweed, Centaurea squarrosa, A, drawing showing habit of plant; B, individual head showing fringed bracts. taken from Weeds of Utah, by A. H. Holmgren. Drawing by Kay Hugie Thorne.

SQUARROSE KNAPWEED and its control

D. C. TINGEY

A WEED previously unknown in the state was reported in 1954 to have infested a small acreage of dry land and some adjacent rangelands in the vicinity of Tintic, Utah. The weed was identified as *Centaurea squarrosa* Willd. It has been referred to since as squarrose knapweed. It is also found in California, and this seems to be the extent of the known infestations in this country. How and when it came to Utah is unknown.

Distribution of the Weed in Utah

In 1954, squarrose knapweed was found in varying degrees of density over an area of about 5 square miles of depleted range west of Tintic in Juab County. Since then it has been found in Tooele and Utah Counties.[1] It was observed growing along the highway from Eureka for about 7 miles into Tooele County, along the foothills into Utah County as far as Elberta along Highway 50 and 6, and along the cattle trails over the Tintic Mountains. It has also appeared along Highway 50 and 6 from Tintic to Jerico, spreading out through the valley for about 30 miles. It is thinly scattered over 4 or 5 hundred acres east of the Star Ranch in northeastern Juab County. A small patch was found along Highway 91 south of Santaquin.

[1] Data on the distribution of squarrose knapweed in the state was supplied by Elmer D. Taylor, district agricultural inspector, Provo, Utah.

Description of the Plant

A native of Eurasia, squarrose knapweed is a long-lived, deep rooted perennial. It has a central taproot with large lateral branches but fortunately does not produce a creeping root system as does its relative, Russian knapweed. New spring growth develops from crown buds similar to those of alfalfa. The basal leaves are deeply dissected and the small leaves above are entire and often turn downward. Stems of the weed are excessively branched and from 12 to 18 inches in height. Each branch terminates in a head of flowers. Individual flowers are purplish to pink in color. Seed heads usually contain from 2 to 3 seeds. At times many of the heads are without seeds, probably due to drought or frost. Bracts of the seed head each terminate in a sharp spine. When wet the spines become soft and pliable.

Seeds are about 1/8 inch long, flattened, medium brown to almost white in color with striations their full length, and with a bristly pappus about half as long as the seed.[2] Seeds remain in the head at maturity and even after the heads break off and fall to the ground. Some seeds are undoubtedly lost from the heads as they are moved by the wind; however, most seem to remain in the head until it decomposes. Seeds taken from heads known to be at least a year old had a clear bright color with the striations as distinct as those of new seed.

[2] Arthur H. Holmgren. Weeds of Utah. Utah Agr. Exp. Sta. Spec. Rept. 12. 1958, p. 71.

Area Where Experiments and Observations Were Made

As a result of several public meetings held at Nephi in 1954, under the auspices of the county weed committee, the Utah Agricultural Experiment Station agreed to conduct experiments on the control of squarrose knapweed. The experiments to be located on an infested area near Tintic, Utah, were planned for the following spring.

To gain information on the plant and to collect seed and plants for greenhouse studies, the infested area was visited in November 1954.

Previous to 1954 about 200 acres of native vegetation had been plowed for dryland wheat production. Wheat had not been successful largely because of the low precipitation which is estimated to be from 7 to 10 inches annually and the area was being infested with plants of low forage value, among them squarrose knapweed.

Various areas of the plowed field had been tilled differently by the farmer in 1953 and 1954. Area 1 had been disked in the spring and fall of both years, area 2 had been disked in the spring and fall of 1953 only, and area 3 had been disked in the spring and fall of 1953 and in the late spring or early summer of 1954. A one-way disk or wheatland plow had been used; this had left many of the squarrose knapweed plants uncut.

Knapweed plants examined in the three areas were developing new shoots from taproots left in the soil; these been cut off well below the crown. In areas 1 and 2 the plants that had been cut off before 1954 had developed shoots from adventitious buds and this tissue was functioning as a crown. In area 2 knapweed had produced a good crop of seed and there were numerous seedlings among the old plants. In area 3 the plants that had been cut off in 1954 were also developing new shoots from the tap root that had remained in the soil.

Top portions of the plants in area 3 that had been cut off and covered with soil had all died. Apparently the soil had been disked in late spring when there was not enough moisture left in the surface soil to support re-growth from crown buds.

These observations led to the conclusion that while squarrose knapweed has a central tap root similar to that of alfalfa, it differs in being able to develop new shoots from adventitious buds arising from tissue cut well below the crown buds. This characteristic would make it more difficult to control than alfalfa.

Observations were also made at two locations in native vegetation. These were designated as areas 4 and 5. The native vegetation was a sagebrush-grass type, typical of the foothills of the Intermountain Region. Both areas, heavily grazed by sheep, had been invaded by squarrose knapweed.

In area 4, adjacent to area 3, the squarrose knapweed plants were unusually large and thrifty. Some of the old plants had taproots that measured 2 to 3 inches in diameter and tapered to ¼ to ⅜ inch at a depth of 8 to 10 inches. Lateral roots ranged up to ½ to ⅝ inch in diameter. There were numerous seedlings of squarrose knapweed all among the sagebrush in area 4.

Area 5 was near the railroad tracks and had been sprayed with 2,4-D by the county in 1954 to kill the knapweed. Some of the treated plants showed new crown growth. A few were dug up and the roots examined. Some of the roots appeared normal, others were fibrous, and some had died. These sprayed plants did not produce seed in 1954.

ROOT STUDIES

A NUMBER of squarrose knapweed plants were dug up and the tops cut off at the crowns. The tops were discarded and the remaining portions were then placed in wet burlap grain bags for transport to the laboratory for further study. Two main objectives of the root studies were to determine at what depth squarrose knapweed roots removed from the soil would develop new shoots from adventitious buds, and whether new plants would develop from cut portions of the taproot.

Sections of the roots were cut at various depths below the crown and placed in moist sand for about 2 months. Some of these sections developed shoots that made some surface growth; some, cut 8 inches below the crown, developed adventitious buds that gave rise to shoots. Many shoots that emerged died later, and examination showed that the old root had rotted without developing any new ones to support the new shoots. It would appear from these studies that some plants removed from the soil and cut 8 inches below the crown can develop adventitious buds from which new shoots can arise, thus permitting the plant to become re-established. Also, new plants can develop from cut portions of the root.

None of the roots taken from plants that had been treated with 2,4-D recovered when placed in the greenhouse under favorable conditions for growth.

As an adjunct to the greenhouse studies, a number of squarrose knapweed plants in areas 2 and 4 were cut off with a shovel at 4, 6, and 8 inches below the surface of the soil. These were staked and labeled to facilitate checking for re-growth in 1955. Most of those cut at 4 or 6 inches below the surface developed new shoots in 1955, but none cut at a depth of 8 inches developed new shoots. Conclusions drawn on the basis of such a small sample may be misleading; however, it did appear that if squarrose knapweed was cut as deep as 8 inches a high proportions of the plants could be killed. This general conclusion also seemed to be borne out by the field experiments reported in a later section of this paper.

SEED GERMINATION STUDIES

SEED was obtained from plants in areas 1 and 2, and from soil collected in areas 1, 2, and 5. These were for studies designed to determine whether squarrose knapweed seeds possessed dormancy, and if the life of the seed might be of short duration in soils. This information would have an important bearing on the problem of control. In area 1, soil was taken at some distance from knapweed plants. This area had been disked in the spring and fall of 1953 and 1954. Seed screened from such soil was assumed to be a year old or older. In area 2, which had been disked in 1953 but not in 1954, soil samples were taken from directly under the plants and also from areas away from the plants after the surface inch of soil had been removed. Seed in these soil samples could not have been produced in 1954 and so would be at least a year old. Plants on area 5, because of the 2,4-D treatment, did not produce seed in 1954. A sample of the duff from under these treated plants was collected. Seeds separated from this material would be a year

TABLE 1. Number of seeds and percentage germination in 60 days for squarrose knapweed from various locations in an infested field near Tintic, Utah (1954)*

	Source of seed	Enc. or not enc. in the head	Year seed produced	Total seeds	No. of seeds germinating	% germinating
Area 2						
Area not disturbed in 1954	From mature plants	Enclosed	1954	100	44	44
	From soil under plants†	Enclosed	1953 or older	34	8	24
	From soil under plants†	Not enc.	1953 or older	30	1	3
	From soil away from plants†	Not enc.	1953 or older	41	0	0
Area 1						
disked in 1954	From plants	Enclosed	1954	43	17	39
	From soil away from plants	Not enc.	1953 or older	29	0	0
Area 5						
Sprayed in 1954 with 2, 4-D	From litter under plants	Enclosed	1953 or older	6	2	33
	From litter under plants	Not enc.	1953 or older	100	1	1

*Soil samples consisted of about 6 pounds taken from about 100 locations.
†Surface inch of soil discarded before sampling.

old or older. Samples collected from the different areas were taken to the laboratory where the seed heads and seeds of squarrose knapweed were separated from the soil and duff by washing and screening. Seed taken from heads and seed free of the heads were placed to germinate on moistened blotter paper in petri dishes at room temperature. The percentage of seed that germinated from the different samples are listed in table 1.

Current-season seed from mature plants gave a 44 percent germination, indicating some seed dormancy. Seed that had been enclosed in the seed head, and was assumed to be one year old or older, germinated about half as well as seed of the new crop. Seed obtained from soil samples, not enclosed in the seed head, and assumed to be at least a year old, gave only a 3 percent germination. Some of these seeds might have been in the head when the soil samples were taken and became separated during the washing and screening process. Of the 44 seeds obtained from soil samples taken at a distance from knapweed plants, none were in seed heads and none germinated. Seed from areas 1 and 5, at least a year old, and not enclosed in the seed head, also had a low germination.

These data indicate that squarrose knapweed seeds do not persist in the soil for long periods of time.

Greenhouse Studies on Seed Germination

Seeds recovered from soil and free of the head had largely lost their viability, as demonstrated in the tests cited above. It appears that the head helps preserve seed viability. To determine if this is the case, studies were conducted under greenhouse conditions on seed that had been collected in the field from normal plants. This study involved seed free from the head as well as seed that was still enclosed.

The experiment was designed to test both types of seed after they had been held for either 3 or 9 months under various conditions. The seeds were: a) stored in a laboratory, b) placed on the surface of the soil, or c) placed in the soil at a depth of ½ inch. The soil was irrigated periodically but was allowed to become essentially air dry between ir-

TABLE 2. Percentage of seeds of squarrose knapweed germinating when kept under various conditions for 3 and 9 months*

Treatment	After 3 months	After 9 months	% increase
Seeds in head:			
Stored in laboratory	38.0	89.0	130
Placed on surface soil	21.8	28.5	30
Placed in soil ½" deep	26.7	45.2	70
Seed free:			
Stored in laboratory	23.0	77.0	235
Placed on surface soil	17.5	28.7	64
Placed in soil ½" deep	15.2	38.8	155

*Average of 4 replications.

tigations. After the 3- and 9-month holding periods, seeds were recovered from the soil by screening and tested for germination, along with those that had been stored in the laboratory. Percentage of seeds germinating by treatments appears in table 2.

Germination was higher after 9 than after 3 months. Seed free of the head gave a lower germination than seed enclosed. The average difference between the two types was about 8 percent and was statistically significant. However, seed free from the head increased in percent germination between 3 and 9 months nearly twice as much as did enclosed seed. It may be that seeds lose their dormancy faster when free from the seed head. Seed placed on the surface of the soil did not show as much increase in percent germination from 3 to 9 months as those placed in the soil.

EXPERIMENTS ON ERRADICATION

EXPERIMENTS were started in the spring of 1955 to evaluate the effects of various herbicides and tillage on eradication of squarrose knapweed. The experimental plots were located on area 2.

Herbicide Experiments

The experiment consisted of using herbicides at 3 rates, applied at 5 stages of growth. The treatments were made in all combinations except that 2,4,5-T was not available when the application was made at the early seed stage. Herbicides used were: 2,4-D amine, 2,4-D ethyl ester, 2,4-D emulsifiable, and the low volatile ester of 2,4-D, a low volatile ester of 2,4,5-T, and silvex (2-[2,4,5-trichlorophenoxy] propionic acid). Each was applied at rates of 1, 2, and 4 pounds an acres at the following stages of growth, spring rosette (May 21), prebud (June 7), early bud (June 21), early seed (July 11), and dormant (November 5).

Plots were 12 feet x 22 feet 8 inches, or an area equivalent to one square rod. Each treatment was replicated twice. Herbicides were applied with a hand compression sprayer operated at 30 pounds pressure and equipped with a 6-foot boom. Water was the carrier. The herbicide was added to the water, stirred, and applied at a rate of 10 gallons of spray to the acre. Percentage of plants dead in 1956 from one herbicide application in 1955 was based on plant counts, while the density of seedlings on each plot was based on a visual estimate.

A repeat application of the herbicides was made in 1956 on all plots treated in 1955. The seedling population made it necessary to spray over the entire plot. Percentage of plants killed and the density of squarrose knapweed seedlings were both based on visual estimates in 1957.

Tillage Experiments

Tillage experiments in 1955 consisted of plowing at two depths: 3 to 4 inches and 6 to 8 inches. It had been planned originally to plow at both depths at three stages of growth: spring rosette, prebud, and early bud. The large roots and the light tractor used for plowing made it difficult to keep the plow in the ground when plowing to a depth of 3 to 4 inches, so this treatment was made only at the spring rosette stage. The deeper plowing was done at all three stages. Each treatment was replicated 3 times on plots 18 by 50 feet. There was no additional tillage during the 1955 season.

A moldboard plow attached to a light tractor was used for plowing in 1955; however, it was evident that the plow was not rigid enough to cut the roots of some of the plants. In general it did a poor job. The 1956 operations consisted of replowing the 1955 plots on May 15 to a depth of about 8 inches, and some new plots were plowed for the first time to that same depth. A 2-bottom plow attached to a light tractor was used for this tillage, and while it did a better job than was accomplished in 1955, some plants were still left uncut. In addition, on June 30, 1956, a cultivator equipped with 12-inch sweeps attached to a light tractor was used to cultivate all tillage plots. They were cultivated to a depth of 4 to 6 inches. On November 17 it was evident that the farm leasee had disked over all tillage and herbicidal plots with a one-way disk.

EXPERIMENTAL RESULTS

Control With Herbicides

PERCENTAGES of plants killed by one application of herbicides made in 1955 are shown in fig. 1. Herbicides, stage of growth, rate of application, and herbicide x stage were all significant at the 1 percent level. Stage x rate and the second order interaction of herbicide x stage x rate were significant at the 5 percent level. It is evident from the figure that the most susceptible stage of growth was pre-bud. Based on the averages of all herbicides and rates, 87 percent of the plants were killed when sprayed at prebud, 76 percent at spring rosette, 72 percent at early bud, 46 percent at early seed, and 52 percent when dormant.

The low volatile ester and emulsifiable forms of 2,4-D were the most effective herbicides. As an average of the rates and stages of growth, the low volatile ester and emulsifiable forms of 2,4-D each killed 75 percent of the plants, ethyl ester of 2,4-D killed 68 percent, 2,4,5-T killed 66 percent, and silvex killed 56 percent.

Percentage of plants killed increased as rates of applications increased, and the increases were consistent for the six herbicides since the herbicide x rate interaction was not significant. Percentage of plants killed also increased with the rate of application for each stage of growth, but the increase was not consistent since the stage x rate interaction was significant. A stage x rate interaction resulted because the percentage of plants killed by the three rates differed least when applications were made at the most susceptible stage of growth, which was pre-bud. A similar relation existed between herbicides and stage of growth. Smaller differences existed between herbicides when applications were made at the most susceptible stage of growth; this situation resulted in a significant interaction between these two variables.

A retreatment in 1956 similar to the one in 1955 was made to try to eliminate the remaining old established plants as well as the young seedlings. Percentage of old plants killed after two treatments during the two years appears in fig. 2. A statistical analysis of the data showed herbicide, rate, date, and herbicide x stage all significant at the 1 percent level whereas rate x stage was significant at the 5 percent level. Percentages of plants killed by herbicide as an average of the three rates and 5 stages of growth were as follows: 2,4-D emulsifiable 89, 2,4-D low volatile ester 88, 2,4-D amine 86, 2,4-D ethyl ester 84, 2,4,5-T 83, and silvex 78. Thus, all of the 2,4-D herbicides were about equally effective. There

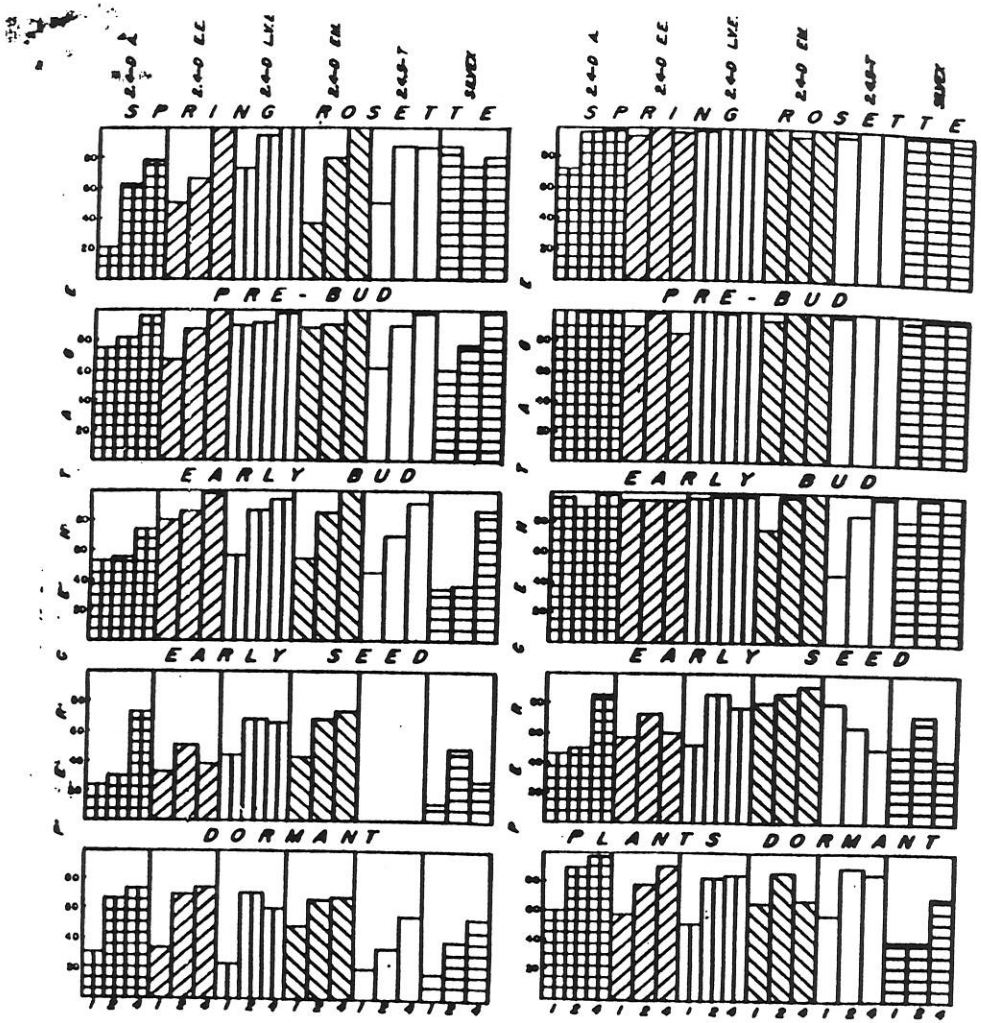


Fig. 1. Percentages of squarrose knapweed plants killed with one application of different herbicides applied at three rates 1, 2, and 4 pounds to the acre and at five stages of growth, spring rosette, pre-bud, early bud, early seed, and dormant. (2,4,5-T not applied at the early seed stage

Fig. 2. Percentage of squarrose knapweed plants killed with two applications in two years. Herbicides were applied at three rates and at five stages of growth (2,4,5-T at the early stage applied only the second year)

was an increase in percentage of plants killed with an increase in rate of application from 1 to 2 pounds of about 10 percent from 78 to 88, but no further increase with 4 pounds. For some unknown reason the 3 rates for 2,4,5-T at the early seed stage were reversed in percentage of plants killed as compared with data

for the other stages of growth. A significantly higher percentage of the plants was killed when sprayed at either the spring rosette or prebud stages than at any other time. When the herbicides were applied at these two stages there were smaller differences in their effectiveness as well as in rate of application. This accounted for the two significant interactions of herbicides x stage and rate x stage.

Control of Seedlings

Squarrose knapweed produces an abundant supply of seed. Thus, seedlings were common in the infested area (fig. 3). On herbicidal treated areas the seedling population was usually high enough to assure reinfestation of the land as soon as the old plants were eliminated. Seedlings present when herbicides are applied will usually be killed; however, additional seedlings soon replace them if the soil is moist.

Estimated seedling density in 1956 and in 1957, following the 1955 and 1956 treatments, appears in table 3. Fewer seedlings were found after the second year's treatments than after the first, but there were still enough to re-infest the land. Neither the different herbicides nor their rates of application seemed to have any appreciable effects on seedling density. Stage of growth when herbicides were applied did show some differences. There were fewer seedlings after the earlier applications following the one treatment and after the late application from two treatments.

Fig. 3. General view of the herbicidal treatments on squarrose knapweed near Tintic, Utah, showing differences in effectiveness. Where old plants have been killed, seedlings are common and appear as the dark areas in the photograph.

TABLE 5. Percentage density of squarrose knapweed seedlings in 1956 following one application of herbicide in 1955, and density in 1957 following a second application in 1956

	1956							1957							
	lbs./A			stage of growth*				lbs./A.			stage of growth*				
	1	2	4	a	b	c	d	1	2	4	a	b	c	d	e
2,4-D (amine)	28	55	47	31	29	66	19	12	12	15	10	19	14	14	8
2,4-D (E. ester)	48	53	28	35	22	47	57	12	12	5	14	11	12	9	1
2,4-D (L. V. ester)	45	43	10	22	18	61	71	8	16	11	6	9	20	21	1
2,4-D (emulsifiable)	57	31	25	22	20	31	71	13	16	12	11	-	21	23	-
2,4,5-T (ester)	28	47	21	25	32	64	...	13	15	6	11	13	10	16	-
Silvex	42	55	27	10	17	65	51	11	12	16	18	23	13	1	8
Average	41	47	31	29	23	59	49	12	14	11	12	14	15	25	6

*Stages of growth: (a) spring rosette, (b) pre-bud, (c) early bud, (d) early seed, and (e) dormant.

Control by Tillage

A limited number of tillage treatments were made on squarrose knapweed in each of the two years to determine if this weed could be readily eradicated by such methods. Estimates of the plants killed after the first year's treatments varied from 20 to 80 percent. The deeper plowing resulted in the most effective eradication. Date of plowing was not important.

Estimates of the percentage of plants killed by the various tillage treatments over the 2-year period were made on November 17, 1957. All the treatments had eliminated nearly all the knapweed plants on all the plots. Seedlings were killed by the late tillage.

Planting Crested Wheatgrass on Infested Area

The experimental plots were re-examined in the fall of 1960. All plots, both herbicidal and tillage, had become re-infested with squarrose knapweed to such an extent that it was difficult to relocate the original plots. Crested wheatgrass had been seeded over the entire area about two years earlier and there was a good stand. Seeding with grass such as crested wheat coupled with 2,4-D sprays after the grass has become established seemingly could provide a workable combination for the control of this weed on infested areas where grass could be established.

SUMMARY AND CONCLUSIONS

Squarrose knapweed is a long-lived perennial with a deep central taproot similar to that of alfalfa; however, it is apparently more drought resistant than alfalfa. The annual growth of the knapweed dies down each fall and new growth starts in the spring from crown buds. If the plants are cut 4 to 6 inches below the crown, they may develop a new crown from adventitious buds arising from the taproot. The plants are propagated essentially from seed. Seeds possess some dormancy, but appear to be relatively short-lived in the soil.

Squarrose knapweed plants can be eradicated by repeat applications of 2,4-D or by tillage. Where tillage is used it should be with an implement capable of cutting all the plants at 8 to 10 inches below the surface of the soil. This could be followed by cultivation as needed. One plowing and one cultivation during the season under conditions similar to those west of Tintic are about all that would be necessary. If the plowing was done in late spring, cultivation may not be necessary.

One year of such treatment would eliminate essentially all the established plants. Seedlings will likely be a problem and will require further cultivation or herbicidal treatments for their control.

Herbicides can be useful in eradicating this weed especially on areas that are inaccessible to tillage equipment. Much of the currently infested area in Utah is not readily accessible to tillage. Any of the 2,4-D's applied once each year for two years at a rate of one or two pounds per acre before bud stage did eliminate virtually all the old plants. The low volatile ester or emulsifiable forms of 2,4-D gave the higher percentage kills when only one application was made.

Crested wheatgrass was established on the squarrose knapweed infested areas near Tintic. Whether the grass could crowd out the weed is unknown, but a combination of crested wheatgrass, spraying with 2,4-D after the grass is established, and good grazing management appears to be effective in controlling squarrose knapweed.

BIOLOGICAL WILDFIRE

Invasive noxious weeds have been described as a raging biological wildfire—out of control and spreading rapidly. The devastation from these alien plants includes enormous economic losses to agriculture and irreparable ecological damage to wildlands. Millions of acres have been invaded or are at risk, including rangelands, forests, wilderness areas, national parks, recreation sites, and wildlife management areas.

Wildlife habitat, wilderness, and recreation areas invaded by yellow starthistle.

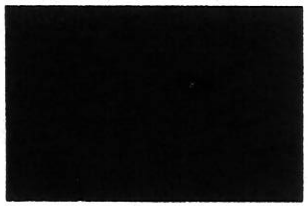
Picnic areas and campgrounds overrun by St. Johnswort.

Wildfires and weeds share much in common, including impacts, spread, and management.

IMPACT:

Like an unwanted wildfire, noxious weeds can drastically affect wildland plant and animal communities, damage watersheds, increase soil erosion, and adversely impact recreation. However, unlike the temporary negative impacts of wildfire, ecological damage from extensive noxious weed infestations is often permanent. Lands affected by wildfire are self-healing, whereas lands invaded by noxious weeds don't return naturally to their pre-invasion condition. Weeds continue to spread and the damage worsens.

Temporary impact of wildfire on plants and animals.



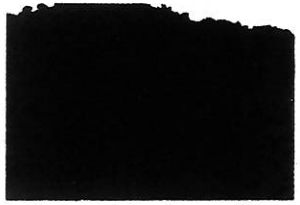
Permanent change in wildland plant and animal community caused by noxious weeds.

When considering long-term ecological effects on the land, invasion by aggressive non-indigenous noxious weeds is far more damaging than any wildfire.

SPREAD:

Weed infestations enlarge and spread much like wildfires, beginning small, then expanding to cover huge areas if not controlled quickly. Weed seeds, like embers, can be carried long distances by wind or other means. The resulting new "spot" infestations grow and merge, much like spot fires ahead of an advancing fire front.

Single leafy spurge plant—the beginning of a new noxious weed infestation.



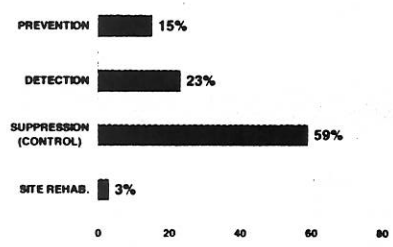
Leafy spurge infestation out of control and expanding.

MANAGEMENT:

Modern wildfire management is based on elements of **Prevention, Detection, Suppression (Control)**, and **Revegetation**; the same fundamentals of effective weed management. A balance of all four elements is essential for effective management of wildfires or weeds.

Resource/budget allocation within effective fire management programs.

A similar balance should exist in weed management programs, with significant efforts in prevention, detection, and revegetation.



PREVENTION:

Prevention is the first line of defense against wildfires, and the same should be true for noxious weeds. The old adage "an ounce of prevention is worth a pound of cure" applies perfectly to both. Weed prevention means placing a priority on preserving and protecting lands not presently infested.

Wildfire prevention depends on widespread public awareness and concern achieved through a balance of education and regulation. Fire prevention messages appear in a variety of forms and places to remind people of the critical role everyone plays in this effort. Regulations such as campfire restrictions contribute significantly to wildfire prevention.

Education and regulation are key ingredients needed to raise public awareness and gain greater support for weed prevention. More land managers and users need to recognize the adverse effects of noxious weeds and become involved in efforts to reduce spread. Informed hikers, campers, hunters, bikers, 4-wheelers, and other recreationists also could do much to prevent the spread of weeds. A significant portion of every weed management budget should be devoted to awareness education and to other forms of prevention.

DETECTION:

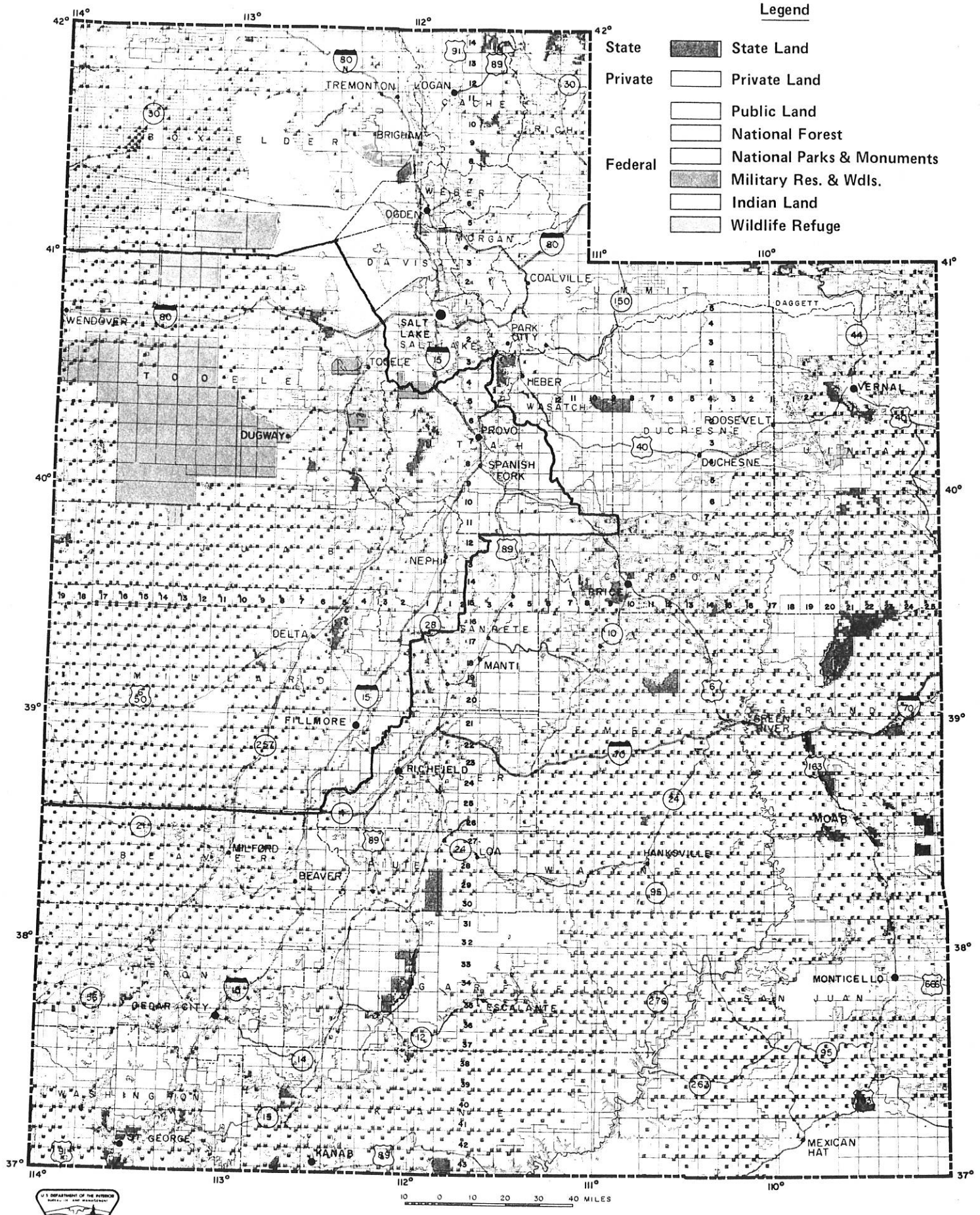
Early detection of wildfires makes rapid and complete control much more likely. The same is true for weeds. Wildfire detection is the primary duty of assigned individuals, but all field personnel within land management agencies are expected to watch for and report wildfires. Weed detection requires field surveys and accurate mapping by designated weed management personnel. As with fire detection, other field personnel could be trained to recognize and report targeted noxious weeds. The public plays a significant role in fire detection and reporting. Ways should be explored to involve volunteer groups, recreationists, and other interested public land users in noxious weed detection and reporting.

SUPPRESSION (CONTROL):

The third element of weed and wildfire management is actual control. Wildfire control activity is called suppression. Fire fighters follow a proven step-wise process of (1) rapid response, (2) size-up, (3) containment, and (4) mop-up. Suppression efforts may fail if all four steps are not completed in proper sequence.

Adoption of a similar four-step approach to noxious weed control could increase the effectiveness and efficiency of almost any weed program.

UTAH LAND STATUS



U.S. Department of Interior
Bureau of Land Management

MEMORANDUM OF UNDERSTANDING
between
Utah State University
Cooperative Extension Service
The
Board of Commissioners
of the Counties of
Juab, Millard, Tooele, and Utah
and
The Utah State Director
Bureau of Land Management

STATEMENT of PURPOSE:

The purpose of this Memorandum of Understanding (MOU), is to establish a framework to increase the cooperative relationship necessary for effective management, coordination and implementation of a Noxious Weed Control and Education program on Squarrose Knapweed between the above listed agencies. The area includes public, state and private lands in Juab, Millard, Tooele, and Utah Counties, within the Salt Lake and Richfield Districts of the Bureau of Land Management.

AUTHORITY

The Federal Land Policy and Management Act of 1976 (FLPMA), P. L. 94-570.

CARLSON-FOLEY ACT of 1968 (P.L. 90-583)

FEDERAL NOXIOUS WEED ACT of 1974 (7 U.S.C. 2801 -2813), as amended by Sec. 15, Management of Undesirable Plants on Federal Lands, 1990.

OBJECTIVES

The objective is to establish a method to develop a coordinated and effective Integrated Pest Management program between all land owners, right-of-ways users, mineral interest groups, and users of the lands for recreation, that will help control and stop the spread of Squarrose Knapweed and other noxious weeds on public, state and private lands in the four county area.

THE UNDERSIGNED PARTIES MUTUALLY AGREE TO:

1. Utilize Noxious Weed Control Guidelines to foster coordination, cooperation, and Action Plan implementation in the four county area.

2. Promote the concept of doing weed management similar to fire management in the prevention, detection and controlling the spread of noxious weeds to enhance the health of the land.

3. Hold a yearly coordination meeting, including field personnel, to develop and revise the yearly action plan. This meeting will be held in January each year and will be scheduled by the BLM State Office. The purpose of the meeting will be to discuss the following:

   a. Develop goals and objectives for inventory and control
   b. Prepare a coordinated Action Plan for the next field season
   c. Provide training and education and
   d. Monitoring effectiveness of work

4. Participate in Noxious Weed Control through exchange of funds, equipment, and personnel, subject to funding allocations received each year. Any exchange of funds will be accomplished through separate agreements at the local level.

5. Work within their own jurisdiction, resources and utilize assistance and expertise of the groups in order to achieve a more effective Squarrose Knapweed control program.

6. Utilize all effective methods of Integrated Pest Management for control and management of Squarrose Knapweed.

7. Provide educational information for the general public, special interest groups and to the staff of the cooperating parties.

8. Be responsive to the cooperators requests for involvement and information for Integrated Pest Management activities on their lands.

9. Provide opportunities to outside interest groups and the public for involvement in carrying out Noxious Weed activities on lands within the Project Area.

This memorandum will become effective as soon as it is signed by all parties and shall continue in force for 7 years unless terminated by mutual written consent of all parties. Any party may withdraw from this agreement at any time by providing 90 days' written notice to all parties.

A review of this MOU will be made at the yearly meeting to make revisions and updates as necessary to meet the purpose of this agreement. Amendments shall become effective upon written approval by all parties.

J. William Lamb		10/16/95
Utah State Director	BLM	Date
Diane Hoffman		11/25/95
District Manager	Salt Lake BLM	Date
Jerry W Goodman		11-1-95
District Manager	Richfield BLM	Date
[illegible] Hunsaker		11-6-95
County Commissioner	Tooele County	Date
[illegible] Herbert		
County Commissioner	Utah County	Date
Gordon Haveng		1-19-96
County Commissioner	Juab County	Date
[illegible]		12-18-95
County Commissioner	Millard County	Date
[illegible]		2-7-96
Cooperative Extension Service		Date