Exotic plants and fire in Colorado

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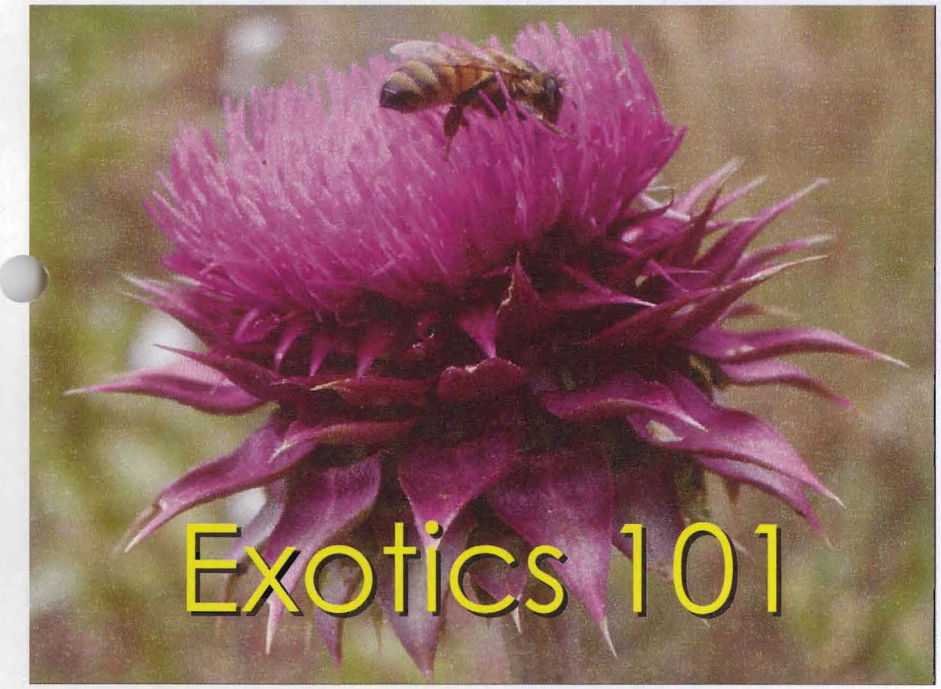
Overview of today's talk

- Exotics 101
- Fire Ecology 101
- Fire, exotics, and Colorado ecosystems
- The fire alternative: restoration, exotics and ponderosa pine forests
- In summary: What we know we know; what we know we don't know



Exotics 101

What is an exotic species?

Exotic species: Organism that is not native to a particular country or ecosystem

Synonyms: non-native, introduced, alien

My bias is plants but any kind of organism can be exotic (e.g. white pine blister rust, emerald ash borer, moose?)

What is an exotic species?

Weed: generic term for a plant growing in a spot where it's not welcome

- Not all weeds are exotic
- Not all exotics are weeds
- To a gardener, an undesirable plant in a flower bed, lawn
- To a rancher, any plant which is especially prolific and which has no use to livestock
- To a botanist, a plant which is especially adept at quickly colonizing natural systems

What is an exotic species?

Invasive weed: A species that moves in and takes over an ecosystem to the detriment of other species. Invasives often obtain 'noxious' status....

Noxious weed: defined by law as being especially undesirable, troublesome, and difficult to control. ~85 plants have been classified as noxious weeds by the state of Colorado.

What is an exotic species?

Characteristics of most exotics:

- Plastic—adapted to grow in multiple environments
- Prolific seeder

Field bindweed	50 seeds/plant
Canada thistle	680
Kochia	14,600
Crabgrass	53,000
Mullein	223,000

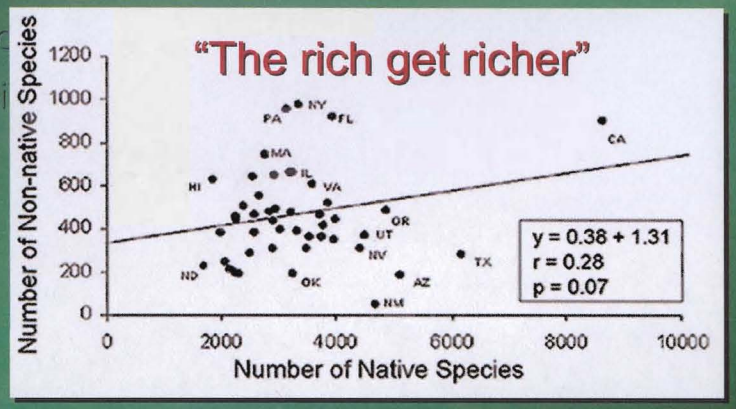
What is an exotic species?

Characteristics of most exotics:

- Superior competitor for resources (light, water, nutrients)
- Lack of natural predators

Where do we find exotics?

- Species-rich areas
- Populated/accessible areas
- Disturbed areas



Stohlgren et al. 2003. Front Ecol Envir 1(1): 11-14

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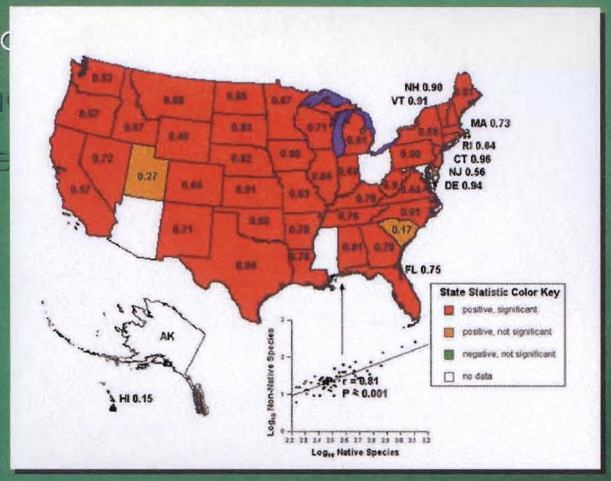

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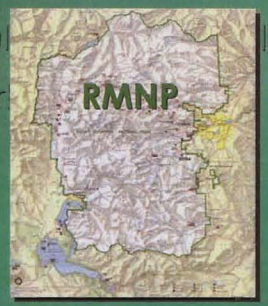


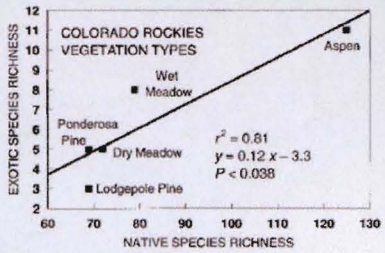


FIG. 7. Relationship of native species richness to number of exotic species at vegetation-type and biome scales (based on combined species lists from 1000-m² plots).

Stohlgren et al. 2003. Ecol Mono 69: 25-46

Where do we find exotics?

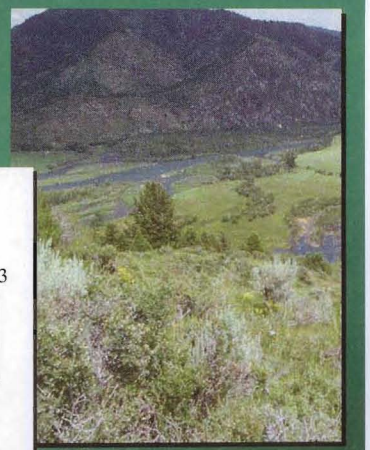
- Species-rich areas
- Populated/accessible areas
- Disturbed areas

Non-native species cover (%) at Turkey Creek

Adjusted R^2: 0.33

Native species richness (spp/plot) $\xrightarrow{+0.59}$ Non-native species cover (%)

1000 m² plots



Fornwalt et al. 2003. For Ecol Mgt 177: 515-527

Where do we find exotics?

- Species-rich areas
- Po
- Di

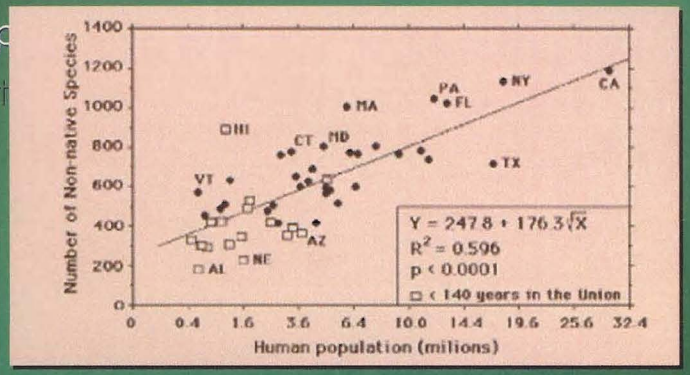
Correlation between native and exotic richness in Mesa Verde National Park

Plot size (m^2)	Correlation coefficient (r)	P-value	n
1	−0.042	>0.05	619
10	−0.026	>0.05	123
100	0.324	0.01	60
1000	0.534	<0.01	54

Hanna et al. 2006. Int J Wildl Fire 15: 247-259

Where do we find exotics?

- Species-rich areas
- Pop
- Dist



Rejmanek. 2003. Front Ecol Envir 1(3): 122-123

Where do we find exotics?

- Species-rich
- Populated/a
- Disturbed are

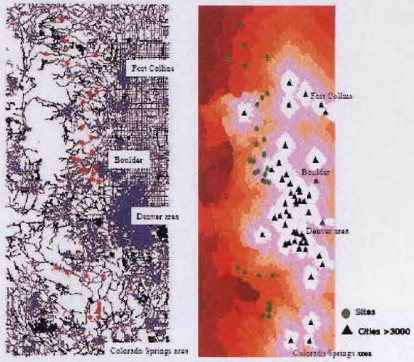
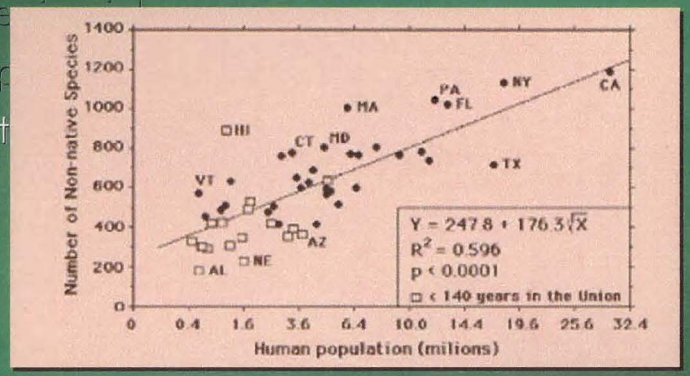


Figure 2.1. Site locations (a) with Front Range roads and (b) with driving distance from larger cities to all site locations along the Front Range (white to dark is shorter to longer driving distance in meters, i.e., decreasing accessibility).

Adair. 2005. PhD Disseration, CSU.

Where do we find exotics?

- Spe
- Pop
- Dist



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Where do we find exotics?

- Species-rich areas
- Populated/accessible areas
- Disturbed areas

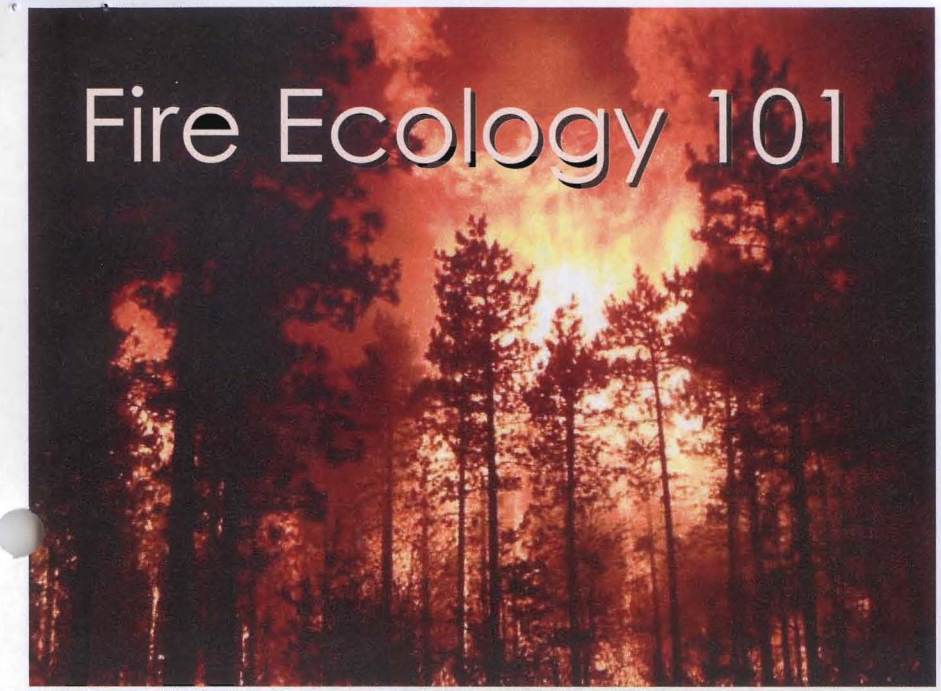
Where do we find exotics?

Where do we find exotics?

- Species-rich areas
- Easily-accessible areas
- Disturbed areas
  - How does fire benefit exotics?
    - Fire exposes bare soil
    - Fire increases nutrient availability
    - Fire reduces competition from natives

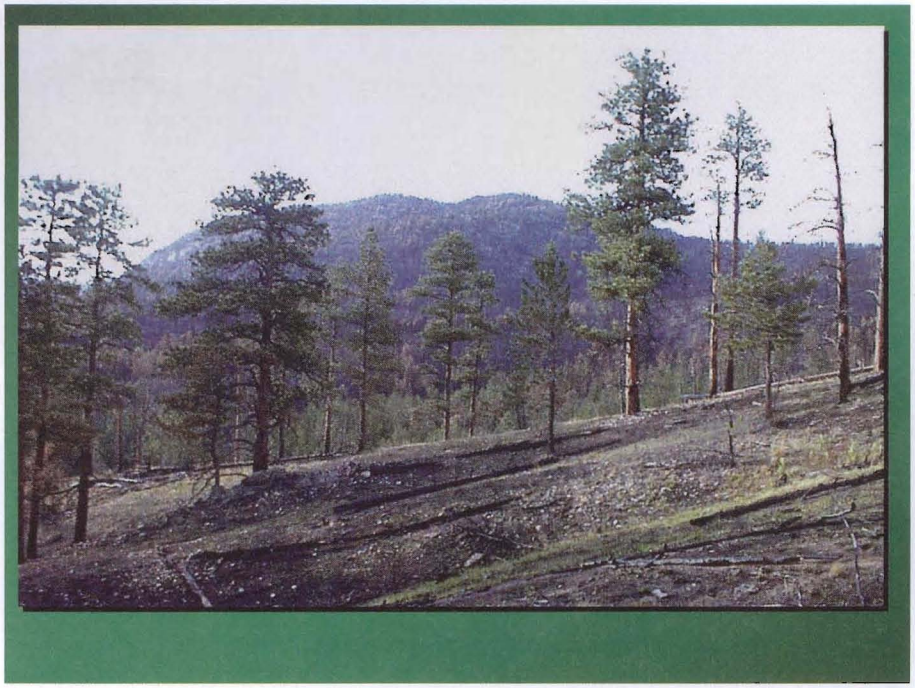
Where do we find exotics?

- Species-rich areas
- Easily-accessible areas
- Disturbed areas
  - How do exotics benefit fire?
    - E.g., cheatgrass in western rangelands has altered fire regimes
    - The fires are so frequent that the native shrubs cannot recover
    - In many places there is now only a sea of cheatgrass!

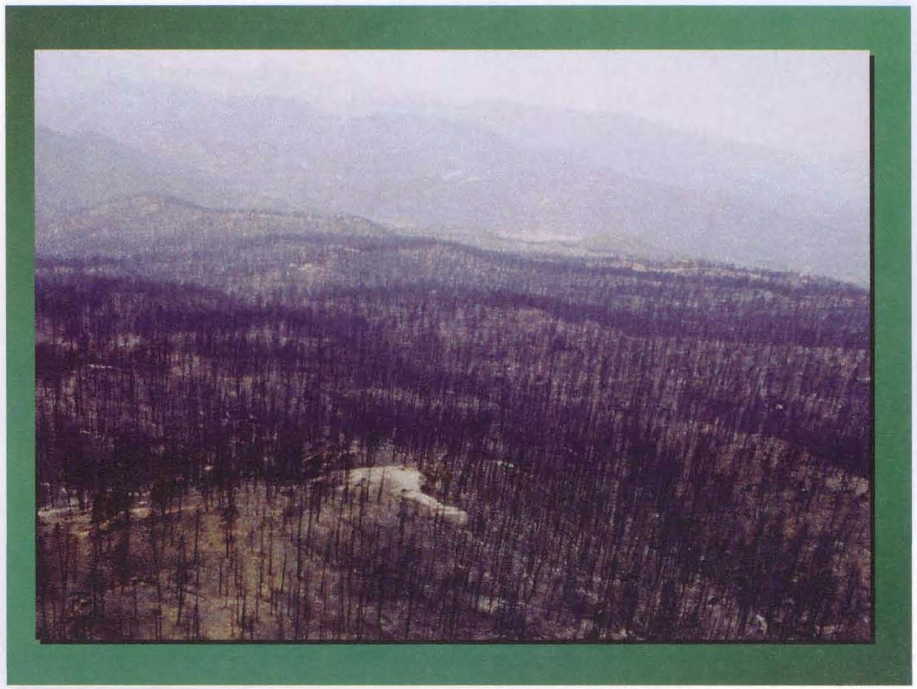


Fire regimes

- Fire regime: an all-encompassing term that integrates several characteristics of fire occurrence for an area
  - Fire severity
  - Fire interval (time between fires for a location)
  - Fire size

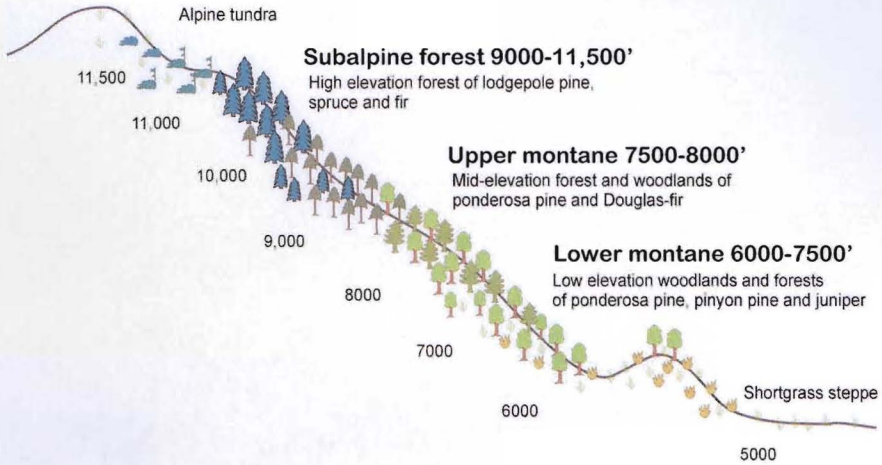


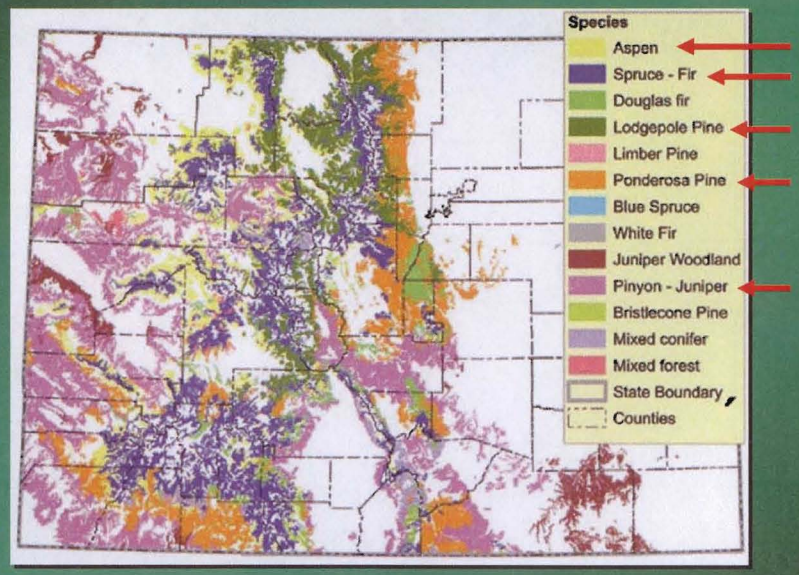
Crown fire



Mixed severity fire

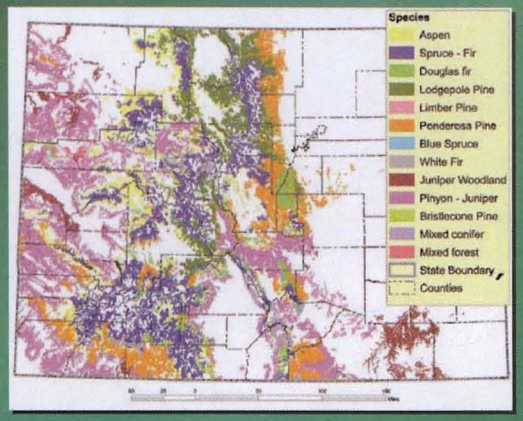
Colorado's ecosystems





Also discussed today: Grasslands, Shrublands, Riparian areas

Grasslands, shrublands

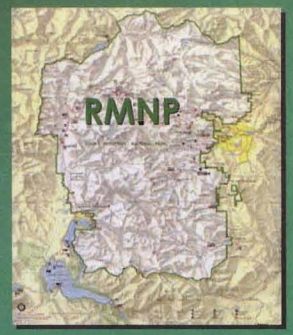


Grasslands and shrublands cover nearly half of Colorado

Fire regime: historically, fire burned every few years in grasslands and every few decades (centuries?) in shrublands, though most are suppressed now

Unburned areas are being somewhat invaded, especially where grazing is heavy

Grasslands, shrublands



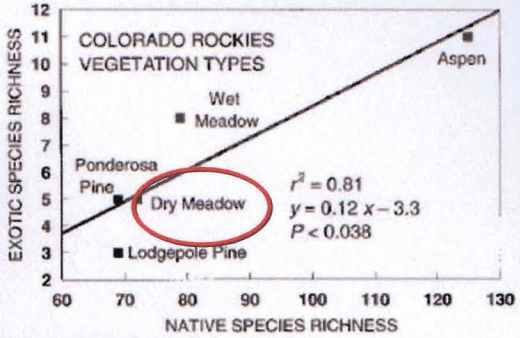


FIG. 7. Relationship of native species richness to number of exotic species at vegetation-type and biome scales (based on combined species lists from 1000-m² plots).

Stohlgren et al. 2003. Ecol Mono 69: 25-46

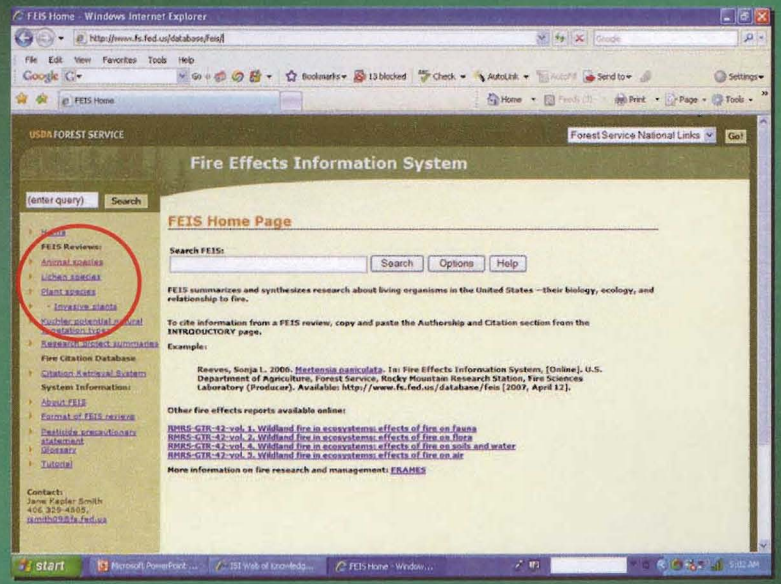
Grasslands, shrublands

Available research:

Vegetation responses to wildfire in native versus exotic Arizona grasslands (Bock & Bock. 1992. J Veg Sci 3: 439-446)

Bromus tectorum (FEIS: www.fs.fed.us/database/feis)

Tangent: FEIS



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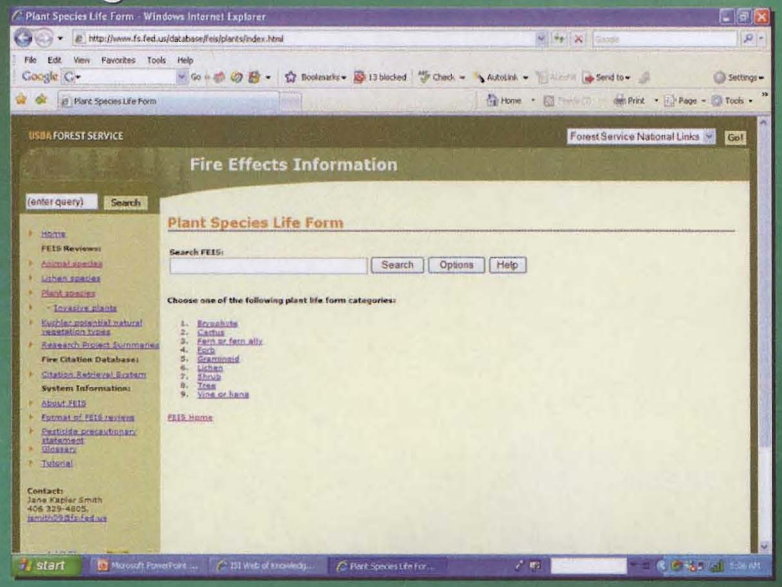

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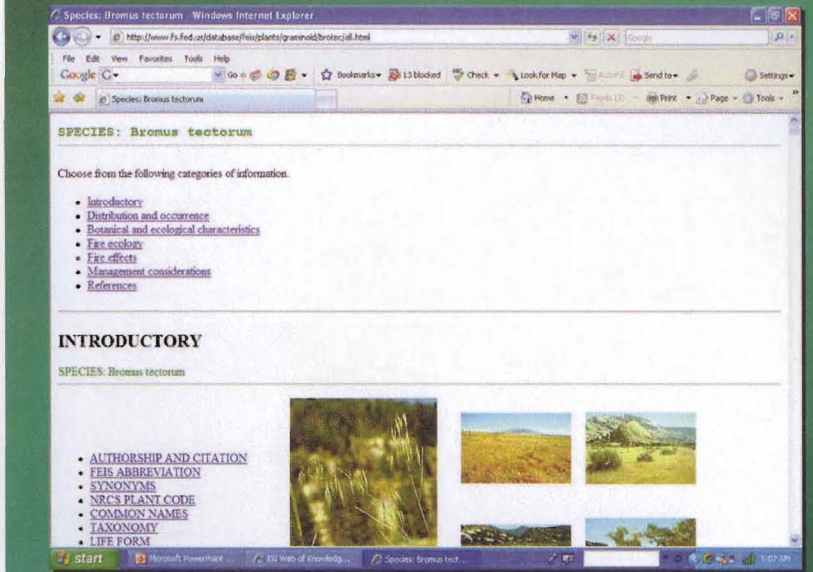

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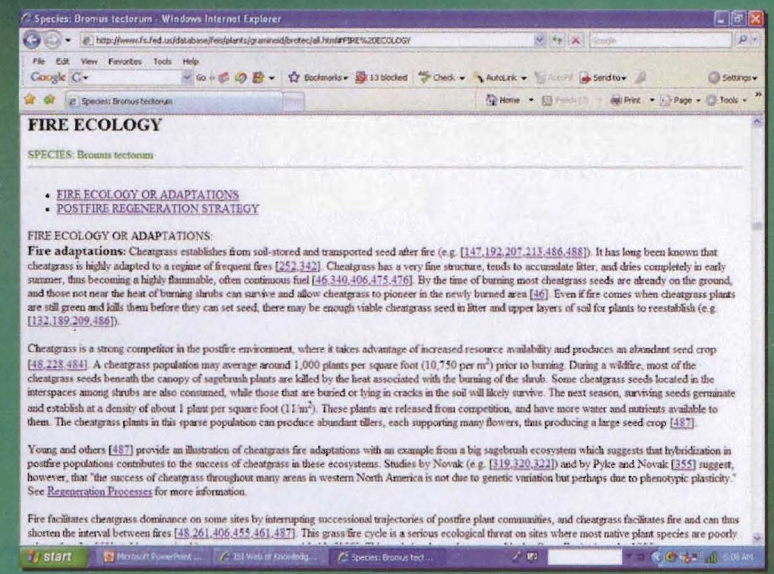

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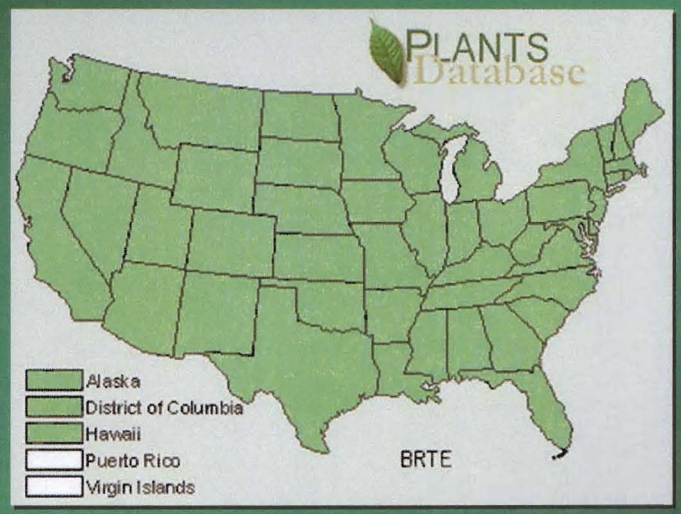

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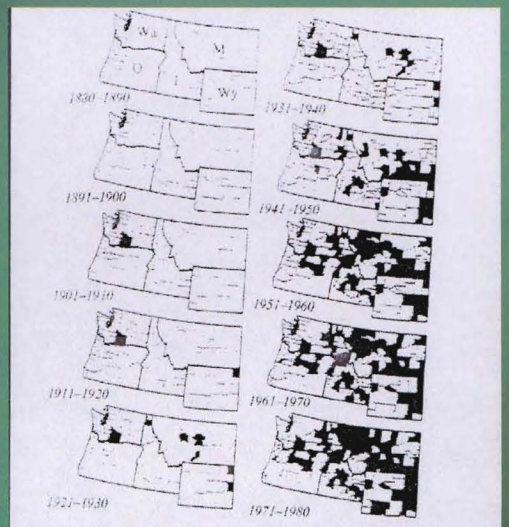


Fig. 2.5. Spread of *Bromus japonicus* in north western USA, compiled from herbarium records (from Forcella & Harvey, 1988). The outlines of the states of Washington (Wa), Oregon (O), Idaho (I), Montana (M) and Wyoming (Wy) are shown.

Bromus tectorum (FEIS: www.fs.fed.us/database/feis)

- Establishes from soil-stored and transported seed after fire
- Has a very fine structure, tends to accumulate litter, and dries completely in early summer, thus becoming a highly flammable, often continuous fuel
- Is a strong competitor in the postfire *environment—takes* advantage of increased resource availability and produces abundant seed

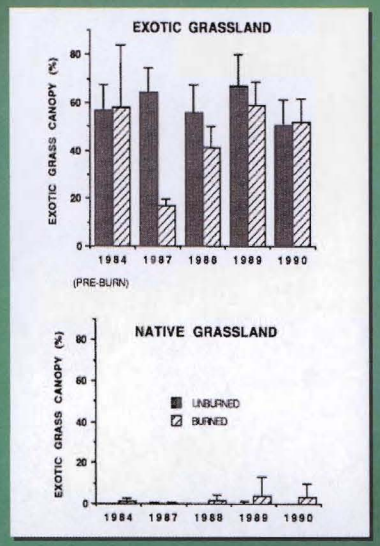
Bromus tectorum (FEIS: www.fs.fed.us/database/feis)

- Cheatgrass expansion has changed fire regimes and plant communities in much of the western rangeland by creating an environment where fires are easily ignited & occur frequently
- Native sprouters may persist for a while, but they cannot tolerate the short fire-free intervals
- Cheatgrass competition prevents their reestablishment

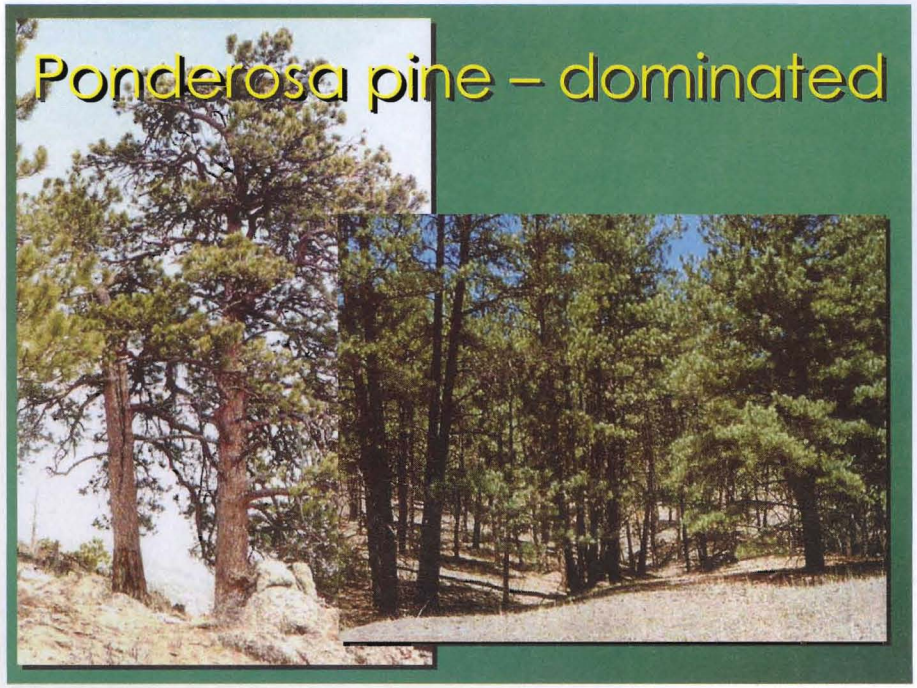
Vegetation responses to wildfire in native versus exotic Arizona grasslands (Bock & Bock 1992)

- Study originally conducted in 1984/5 and designed to compare vegetation in four sites
  - 2 dominated by native grasses
  - 2 by exotic lovegrasses (intentionally seeded 40 y before study)
- 2 years after study was completed, 1 native site and 1 exotic site burned in a wildfire
- Remeasured plots in 1987, 88, 89, 90

Vegetation responses to wildfire in native versus exotic Arizona grasslands (Bock & Bock 1992)



Ponderosa pine – dominated



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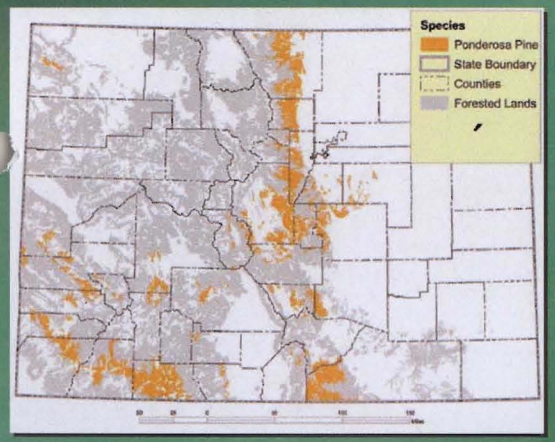


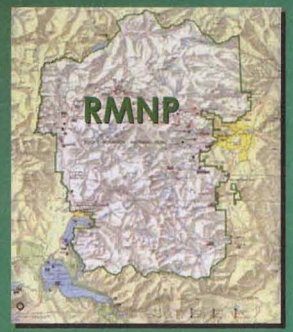
Ponderosa pine is Colorado's dominant lower timberline species and an important source of wood products.

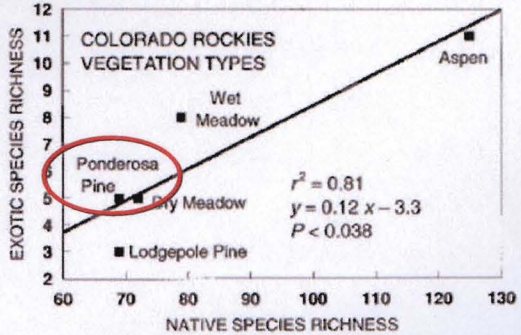
Fire regime:

- Mixed severity fires every 50 y in the Front Range
- More frequent surface fire in southwest CO
- Fire suppression has altered the fire regime in places

Unburned areas are being invaded, but generally at low levels

Ponderosa pine – dominated





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Stohlgren et al. 2003. Ecol Mono 69: 25-46

Ponderosa pine – dominated

Available research:

Responses of exotic plant species to fires in *Pinus ponderosa* forests in northern Arizona
(Crawford et al. 2001. J Veg Sci 12: 261-268)

Exotic species establishment after the 2002 Hayman Fire
(Fornwalt et al. In preparation.)

Effects of the scarify-and-seed postfire rehabilitation treatment on understory plants in the Hayman Fire, Colorado
(Fornwalt and Kaufmann. In review. Fire Mgt Today)

Exotic plant species, fires and northern Arizona ponderosa forests (Crawford et al 2001)

- Sampled 3 large (2800-6500 ha) fires that burned in 1996 in northern Arizona
- Sampling occurred in 1998
- 3 burn severities sampled in each fire:
  - Moderately burned (M): crowns scorched; few trees killed
  - Severely burned (H): nearly all trees killed
  - Unburned: just outside the fire perimeter

Exotic plant species, fires and northern Arizona ponderosa forests (Crawford et al 2001)

- 30 of the 161 plants found were exotic
- Exotics comprised 26% of total ground cover

Table 2. Mean cover (to the nearest percent) of exotic species in unburned (U), moderate (M) and high severity burn (H) plots from three 1996 fires of northern Arizona *P. ponderosa* forests. Blank spaces show the species was absent, 0 indicates cover < 0.5%.

	U	M	H
Annual forbs			
Amaranthus spec.		0	0
Chenopodium album	0	11	39
Cirsium vulgare		0	0
Conyza canadensis		27	18
Dianthus armeria			
Erodium cicutarium			0
Lactuca serriola		1	2
Lappula occidentalis		0	4
Malva neglecta			0
Medicago lupulina		0	0
Melilotus officinalis	0	0	1
Polygonum aviculare		0	0
Salsola kali		0	24
Sonchus asper			0
Teloxys graveolens	0	1	0
Tragopogon dubius	0	0	0
Verbascum thapsus	0	1	5
Verbesina encelioides			0
Verbena bracteata			
Annual grasses			
Bromus tectorum	0	3	19
Perennial forbs			
Lonia corniculatus			
Marrubium vulgare		0	0
Medicago sativa	0	0	0
Taraxacum officinale	0	11	1
Trifolium spp.		0	
Perennial grasses			
Bromus inermis	0	2	0
Dactylis glomerata		0	1
Phleum pratense		0	0
Poa pratensis		1	2
Total	0	59	116

Exotic plant species, fires and northern Arizona ponderosa forests (Crawford et al 2001)

Table 3. Mean cover of important species discriminating between unburned (U) and high severity (H) classes in three 1996 fires of northern Arizona *Pinus ponderosa* forests. Species are listed in order of their contribution (Cum %) to the mean dissimilarity (Di) among samples, up to a cumulative % contribution of 75%. Exotic species are indicated by *.

Species	Mean cover (%) H	U	Di	Di/SD(Di)	Cum (%)
*Chenopodium album**	22.4	0.0	15.0	0.7	15.6
*Salsola kali**	14.6	0.0	11.4	0.5	27.4
Robinia neomexicana	13.9	7.7	9.9	0.6	37.6
Quercus gambelii	16.7	2.5	8.8	0.6	46.7
Muhlenbergia montana	0.0	5.8	3.5	0.4	50.4
Cirsium wheeleri	4.1	0.4	2.9	0.6	53.4
Lupinus argenteus	4.1	1.7	2.8	0.6	56.3
*Conyza canadensis**	2.9	0.0	2.8	0.4	59.1
Vicia americana	4.9	0.5	2.5	0.5	61.7
Lupinus kingii	3.1	0.5	2.5	0.4	64.3
Erigeron divergens	2.9	0.1	2.3	0.4	66.7
Solidago spp.	2.6	0.9	2.2	0.3	69.0
Gayophytum diffusum	4.0	0.0	2.1	0.4	71.2
Carex spp.	0.9	2.2	1.9	0.6	73.1
Polygonum douglasii	2.8	0.1	1.8	0.7	75.0

Most indicative of unburned plots

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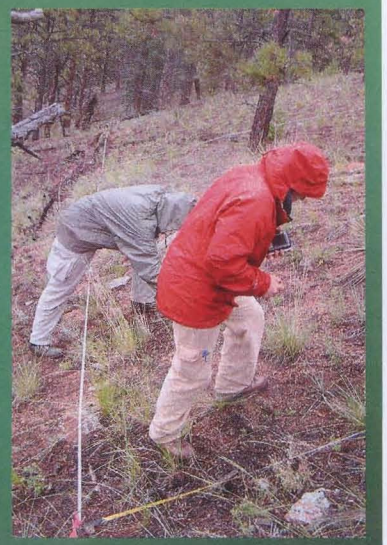
Quercus gambelii	16.7	2.5	8.8	0.6	46.7
Muhlenbergia montana	0.0	5.8	3.5	0.4	50.4
Cirsium wheeleri	4.1	0.4	2.9	0.6	53.4
Lupinus argenteus	4.1	1.7	2.8	0.6	56.3
*Conyza canadensis**	2.9	0.0	2.8	0.4	59.1
Vicia americana	4.9	0.5	2.5	0.5	61.7
Lupinus kingii	3.1	0.5	2.5	0.4	64.3
Erigeron divergens	2.9	0.1	2.3	0.4	66.7
Solidago spp.	2.6	0.9	2.2	0.3	69.0
Gayophytum diffusum	4.0	0.0	2.1	0.4	71.2
Carex spp.	0.9	2.2	1.9	0.6	73.1
Polygonum douglasii	2.8	0.1	1.8	0.7	75.0

Most indicative of burned plots

Exotic species establishment after the 2002 Hayman Fire (Fornwalt et al in prep)

- The Turkey Creek study area is a 4-km^2 study area on the Pike NF
- Originally established in 1996 to study the forest understory
- Study area burned with mixed severity in the 2002 Hayman Fire
- Plots relocated & remeasured from 2003-6



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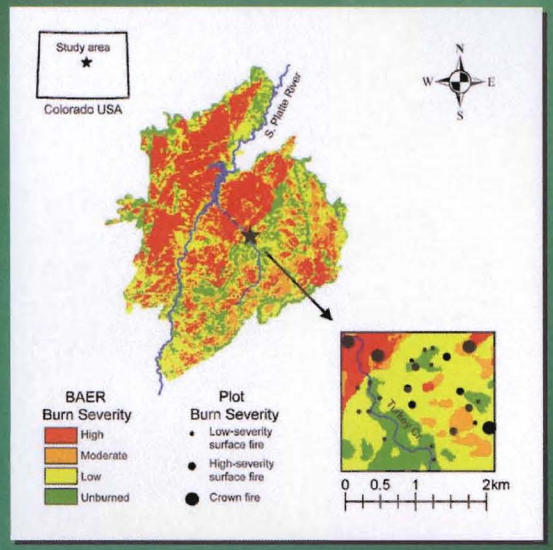
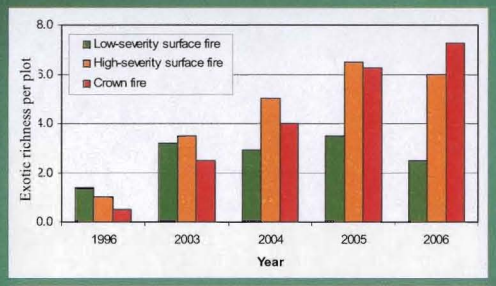
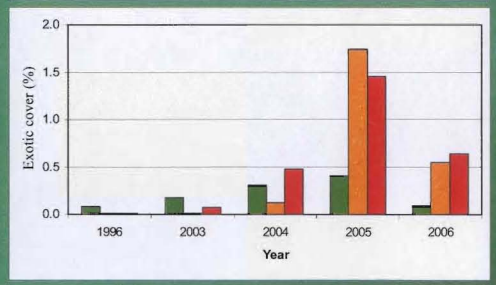


Exotic species establishment after the 2002 Hayman Fire (Fornwalt et al in prep)





Exotic species establishment after the 2002 Hayman Fire (Fornwalt et al in prep)

Species	Low-severity surface fire					High-severity surface fire					Crown fire				
	1996	2003	2004	2005	2006	1996	2003	2004	2005	2006	1996	2003	2004	2005	2006
Agropyron cristatum			<0.1												
Amaranthus retroflexus										<0.1		<0.1		<0.1	<0.1
Arabis glabra															
Arabis hirsuta							<0.1	<0.1	<0.1	<0.1			<0.1		
Axyris amaranthoides		<0.1													
Bromus inermis						<0.1		<0.1	<0.1			<0.1		<0.1	
Camelina microcarpa															
Carduus nutans			<0.1	<0.1	<0.1				<0.1	<0.1					
Cirsium arvense		<0.1	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1	<0.1				<0.1	
Conyza canadensis		<0.1		<0.1	<0.1		<0.1	<0.1	1.3	0.1		<0.1		0.4	0.1
Crepis											<0.1				<0.1
Dactylis glomerata															
Descurainia sophia															
Kochia scoparia															
Lactuca serriola		<0.1	<0.1	<0.1	<0.1		<0.1	0.1	0.2	<0.1		<0.1	<0.1	0.2	
Linaria vulgaris			<0.1			<0.1	<0.1	<0.1	<0.1	<0.1			<0.1	<0.1	
Matricaria discoidea					<0.1										
Phleum pratense								<0.1		<0.1					
Poa annua						<0.1									
Poa pratensis	<0.1	<0.1				<0.1							<0.1		
Polygonum convolvulus									<0.1						
Potentilla norvegica															
Rorippa sylvestris							<0.1								
Sonchus asper													<0.1		
Taraxacum officinale	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.3	<0.1	<0.1	<0.1	0.2	0.2
Tragopogon dubius	<0.1		<0.1	<0.1	<0.1			<0.1	<0.1	<0.1			<0.1	<0.1	0.1
Triticosecale rimpaui		<0.1	<0.1	<0.1			<0.1		<0.1			0.1	<0.1		
Verbascum thapsus	0.1	0.1	0.3	0.4	<0.1		<0.1	<0.1	0.1	0.1		<0.1	0.5	0.7	0.4

Effects of the scarify-and-seed postfire rehabilitation treatment on the understory

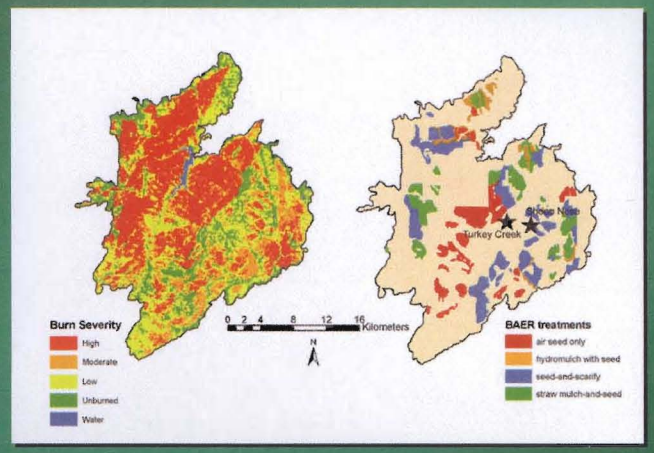
(Fornwalt and Kaufmann in review)

Another study involving Turkey Creek:

- In 2004, we established the Sheep Nose study area in a nearby burned-and-rehabilitated area to assess the ecological impacts of postfire rehabilitation
- The treatment at Sheep Nose was a scarify-and-seed treatment
  - Soil scarification to break up water-repellant layer below soil surface
  - Seeding to provide plant cover and soil stabilization
- Turkey Creek was not rehabilitated and provided a 'burned only' reference condition

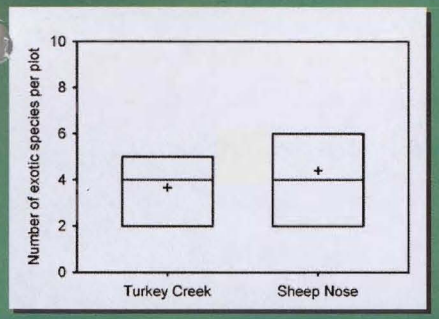
Effects of the scarify-and-seed postfire rehabilitation treatment on the understory

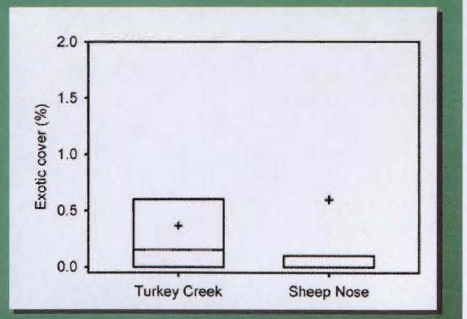
(Fornwalt and Kaufmann in review)



Effects of the scarify-and-seed postfire rehabilitation treatment on the understory

(Fornwalt and Kaufmann in review)





Effects of the scarify-and-seed postfire rehabilitation treatment on the understory

(Fornwalt and Kaufmann in review)

- 6 noxious weeds:
  - Cheatgrass (*Bromus tectorum*)
  - Musk thistle (*Carduus nutans*)
  - Canadian thistle (*Cirsium arvense*)
  - Saint Johnswort (*Hypericum perforatum*)
  - Butter-and-eggs (*Linaria vulgaris*)
  - Mullein (*Verbascum thapsus*)
- All had very low cover-- statistical analysis was unrealistic for first 4 species
- Cover of butter-and-eggs was not statistically different between sites
- Mullein was significantly more abundant in TC than in SN. Could it have been targeted for removal during rehabilitation?

Effects of the scarify-and-seed postfire rehabilitation treatment on the understory

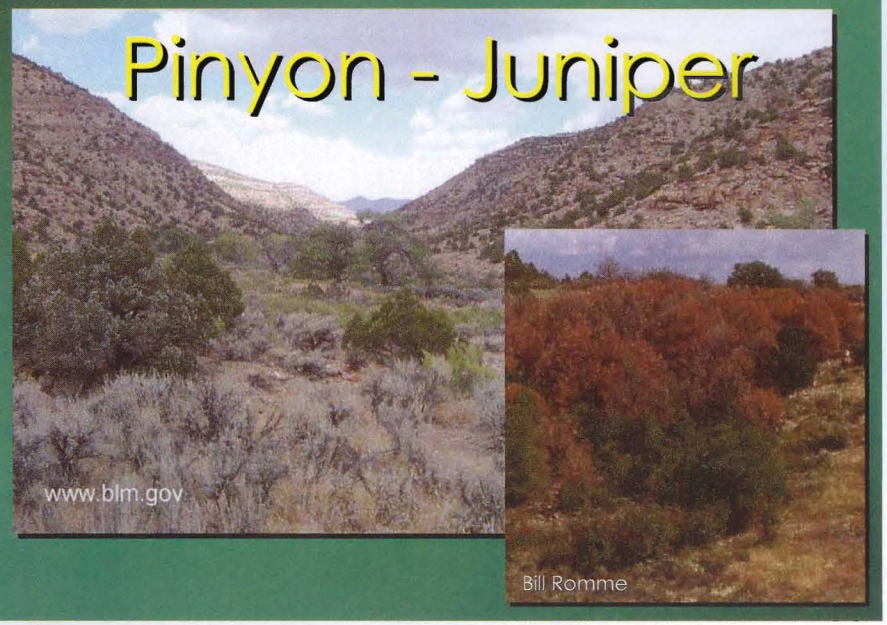
(Fornwalt and Kaufmann in review)

While the scarify-and-seed treatment did not encourage exotic establishment, it is important to point out that:

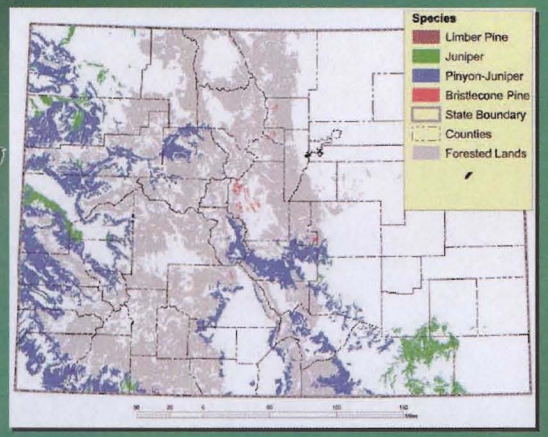
- Seeded grass cover was < 1% in treated plots (max cover in any plot <3%)
- Scarification was not deep; occurred on a relatively small area
- The treatment did not help control erosion

However, others have found that more 'intense' treatments can encourage exotic establishment

Pinyon - Juniper



Pinyon - Juniper



Fire regime:

- Stand replacing crown fires
- 100 y intervals in shrublands
- 400+ years in woodlands
- No effects of fire suppression

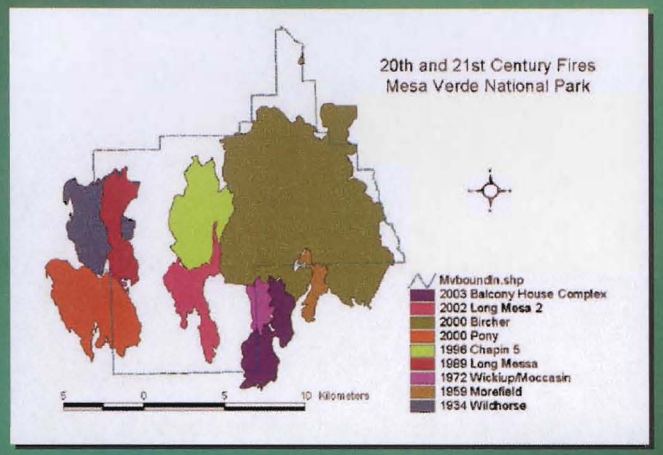
Unburned areas are being invaded, but generally at low levels

Pinyon - Juniper

Available research:

Predicting and mitigating weed invasions to restore natural post-fire succession in Mesa Verde National Park, Colorado, USA (Hanna et al. 2006. Inter J Wildl Fire 15: 247-259)

Predicting and mitigating weed invasions in Mesa Verde
(Hanna et al 2006)



Half of Mesa Verde NP has burned in last 10 y!

Predicting and mitigating weed invasions in Mesa Verde
(Hanna et al 2006)

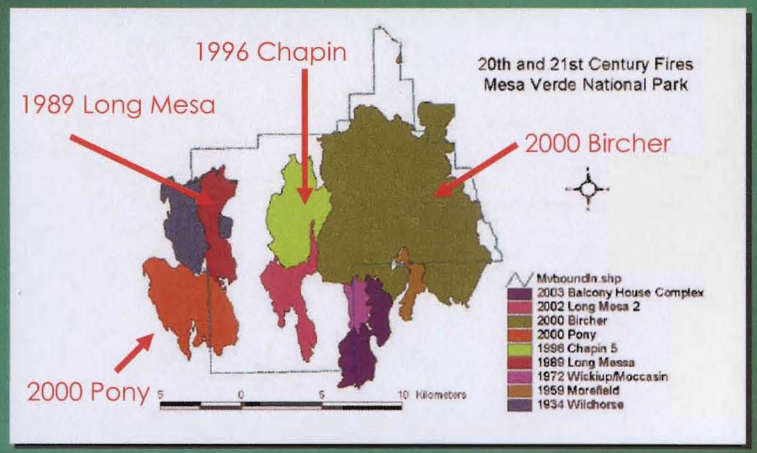
Cheatgrass is on the move in MVNP!

- In 2002, restricted to <7500 ft
- In 2003, found in all burn areas 6800-8600 ft
- A serious threat to ecological integrity
- ...May change the fire regime

Other exotics that have invaded MVNP after fire:

- Musk thistle
- Canada thistle
- others

Predicting and mitigating weed invasions in Mesa Verde
(Hanna et al 2006)



Predicting and mitigating weed invasions in Mesa Verde
(Hanna et al 2006)

Table 3. The density (number per 314 m^2) of non-native invasive plants, primarily *Carduus nutans* and *Cirsium arvense*, 3 years after the 2000 Bircher and Pony fires

Data were collected in 2003 after less than normal precipitation conditions. Values given are mean, standard error. $F = 3.0$, $P = 0.05$, significant difference in non-native density across three treatments

Treatment	Non-native density	Sample size
Unburned	37.5, 22.9	40
Burned	724.3, 361	40

Burned areas were more invaded

Predicting and mitigating weed invasions in Mesa Verde
(Hanna et al 2006)

Table 4. The density (number per 314 m^2) of non-native plants, primarily *Carduus nutans* and *Cirsium arvense*, in 2003, 8 years after the 1996 Chapin 5 fire

The estimated density of *Bromus tectorum* is shown separately.
Data are: mean, standard error

Treatment	Non-native plant density (excluding *Bromus tectorum*)	*Bromus tectorum*	Sample size
Unburned	0.58, 0.29	0.08, 0.28	48
Burned	21.9, 5.3	574.6, 178	114
Significance	$F = 6.7, P = 0.01$	$F = 4.8, P = 0.038$	

Again, more exotics in burned areas

Cheatgrass exploded!

Predicting and mitigating weed invasions in Mesa Verde
(Hanna et al 2006)

Table 5. The number of native and invasive species recorded in sample plots classed by functional group (piñon–juniper lacking prolific sprouting species) and mountain shrubland (prolific post-fire sprouting) in the Long Mesa fire 13 years after fire

Data were collected under extreme drought conditions in 2002.
Data are: mean, standard error

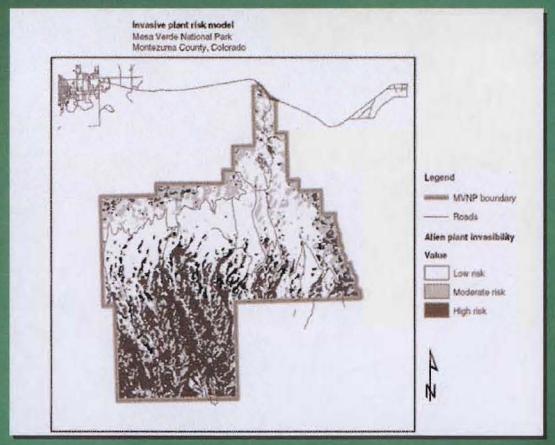
Shrub lands

PJ

Type	Sprouting functional group	Non-sprouting functional group	Statistical significance
Native species	14.6, 3.6	16.4, 4.3	n.s.
Non-native species	0.4, 0.6	2.2, 1.2	$t = 5.3, P < 0.01$
Sample size	29	45	

Communities composed of sprouting species were less invaded

Predicting and mitigating weed invasions in Mesa Verde
(Hanna et al 2006)



Looked at invasions on different soil types

Combined this info with fire, functional group findings to develop risk map

Predicting and mitigating weed invasions in Mesa Verde
(Hanna et al 2006)

Table 8. Comparison of non-native plant density (number per hectare) in burned seeded and unseeded treatments of Park Mesa, Chapin 5 fire, Mesa Verde National Park

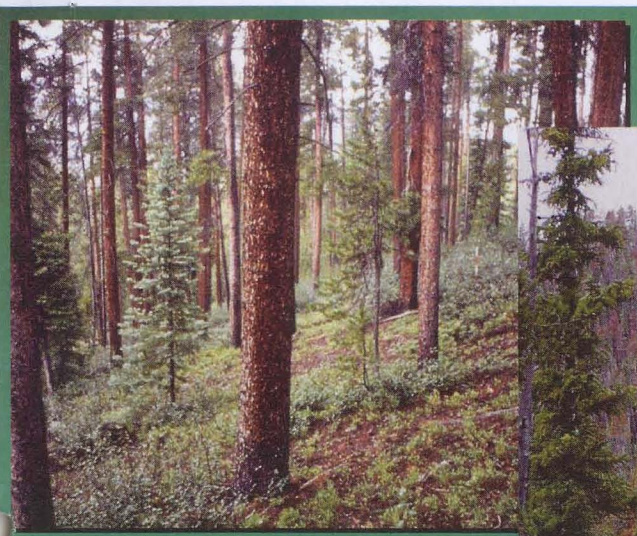
Data are: mean ± standard deviation

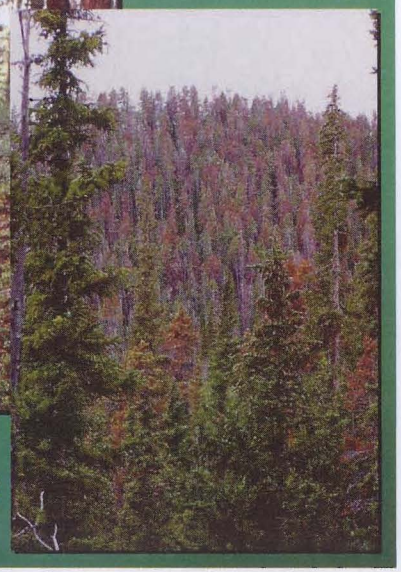
Year of monitoring	Unseeded control	Seeded treatment[a]	No. plots
1998	8000 ± 728	576 ± 602	50
1999	13 373 ± 9301	1779 ± 65	50
2001	6125 ± 1138	3230 ± 5933	26
2003	3596 ± 7515	928 ± 1680	195

[a]ANOVA analyses for each year demonstrate significant differences ($P < 0.05$) between seeded and unseeded burned areas.

Conducted aerial seeding with natives in high risk areas

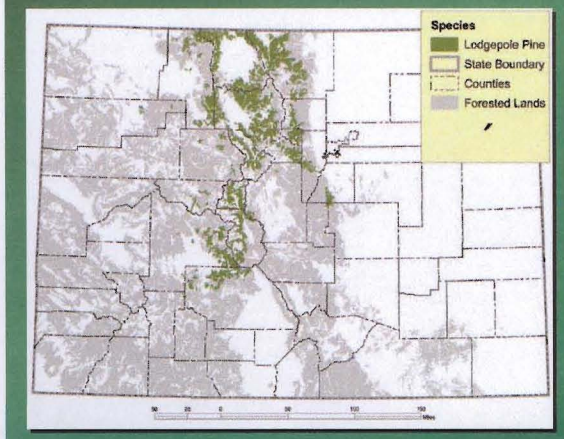
Seeding reduced the density of exotics





Lodgepole pine

Lodgepole pine

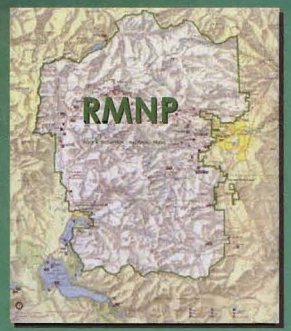


Fire regime:

- Crown fires every 100-300 y
- Fire suppression generally has not increased fire severity

Generally very low levels of exotics in unburned areas

Lodgepole pine



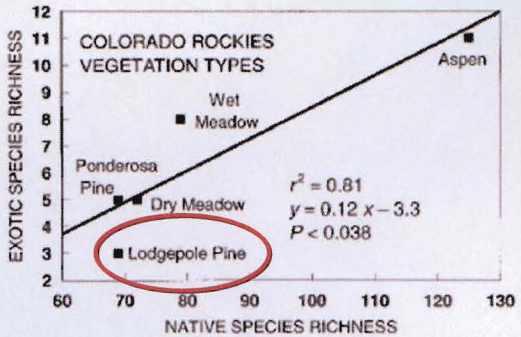


FIG. 7. Relationship of native species richness to number of exotic species at vegetation-type and biome scales (based on combined species lists from 1000-m² plots).

Stohlgren et al. 2003. Ecol Mono 69: 25-46

Lodgepole pine

Available research:

The effects of fire interval on post-fire understorey communities in Yellowstone National Park
(Schoennagel et al. 2004. J Veg Sci 15: 797-806)

The effects of fire interval in Yellowstone National Park (Schoennagel et al 2004)

- Study objective: to assess whether or not understories in areas with a short interval between 2 consecutive fires differed from areas with a long fire interval
- All areas sampled burned in 1988 Yellowstone fires
  - Short interval sites burned in 1988 and 7 y prior (on average)
  - Long interval sites burned in 1988 and 158 y prior (on average)

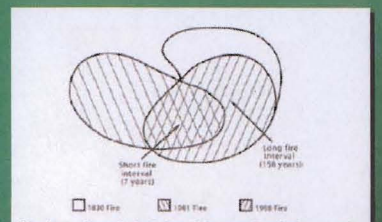
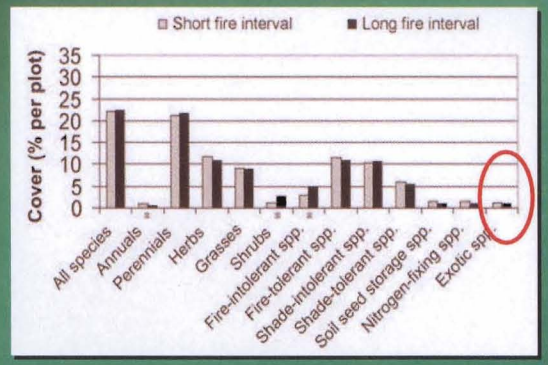


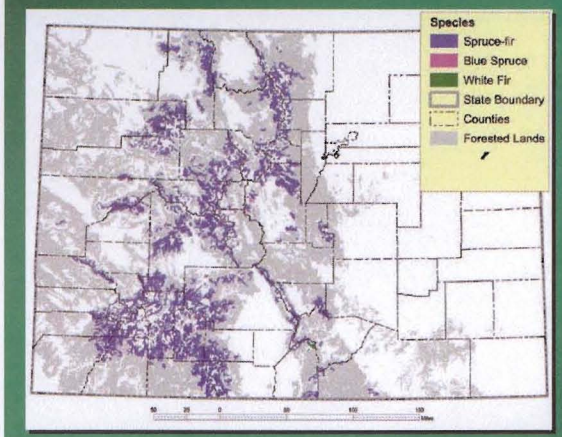
Fig. 2. A schematic depiction of the sampling design at each location with example dates. All sampling occurred in 2000. In this example the short fire interval is 7 yr, whereas the long fire interval is 158 yr. All stands sampled experienced 12 yr since the most recent fire.

The effects of fire interval in Yellowstone National Park (Schoennagel et al 2004)



- Exotic cover did not increase appreciably in short-interval plots

Spruce – fir



The spruce-fir forest type is the most extensive forest type in the state

Fire regime:

- Very infrequent crown fire (fire interval of 300-500 years or more)
- Fire suppression has not affected fire severity

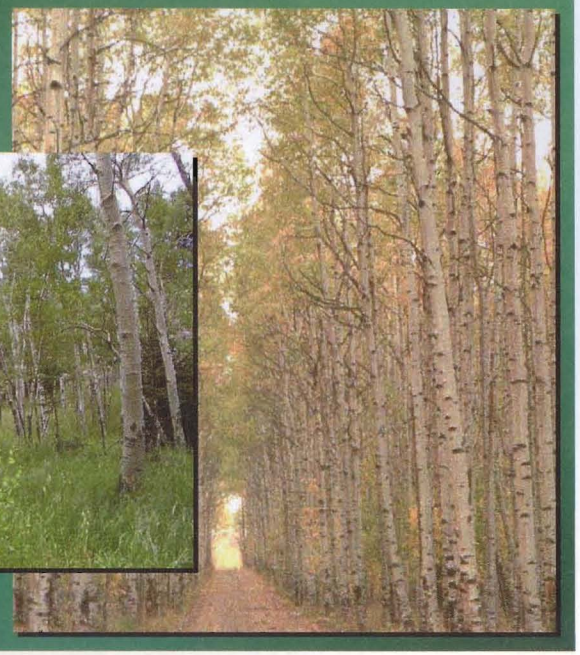
Generally low levels of exotics in unburned areas- harsh growing environment

Spruce – fir

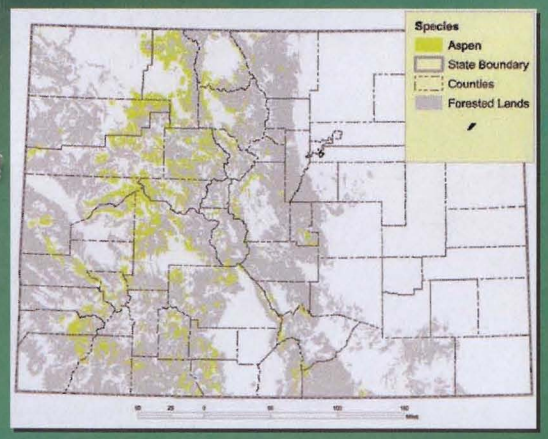
Available research: none found

- My 'best guess':
  - The growing environment, the paucity of exotics in unburned areas, the long fire intervals, and the sprouting ability of the native plants makes the risk of invasion pretty low.

Aspen



Aspen

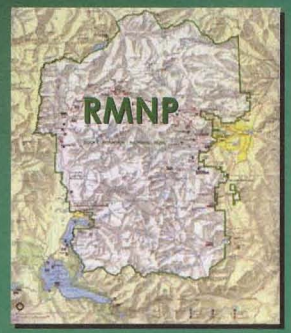


Aspen represents the state's only widespread, native deciduous tree.

Fire regime: Largely dependent on elevation, but fire intervals generally range from 50+ years

Aspen stands have some of the most diverse understories of any Colorado forest type, and many are also fairly invaded

Aspen



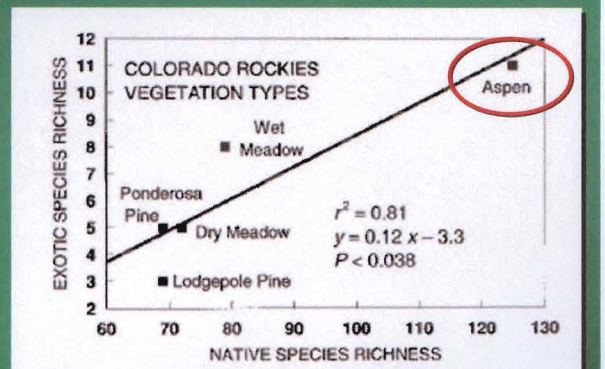


FIG. 7. Relationship of native species richness to number of exotic species at vegetation-type and biome scales (based on combined species lists from 1000-m² plots).

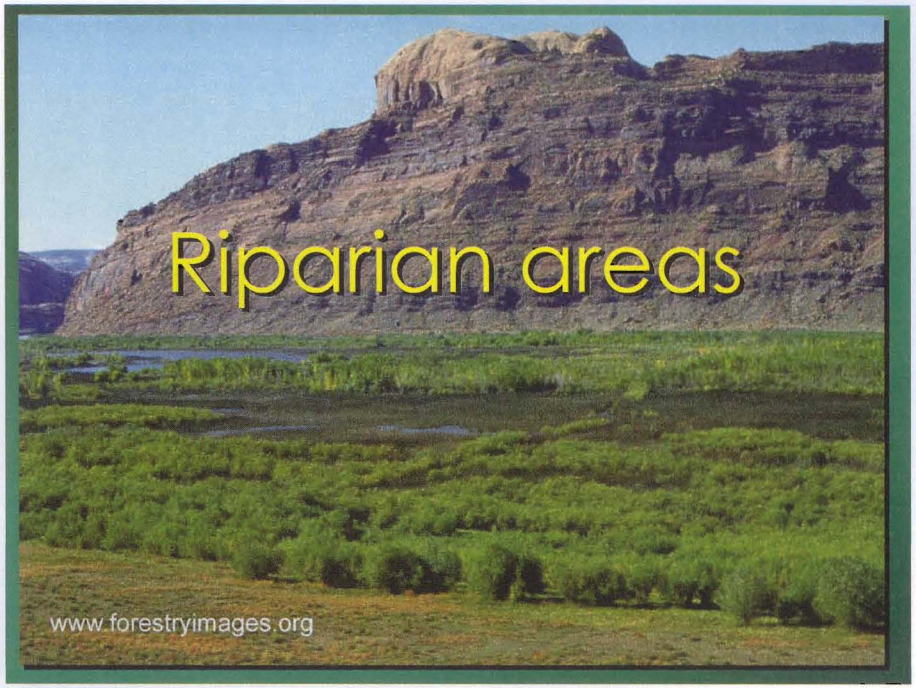
Stohlgren et al. 2003. Ecol Mono 69: 25-46

Aspen

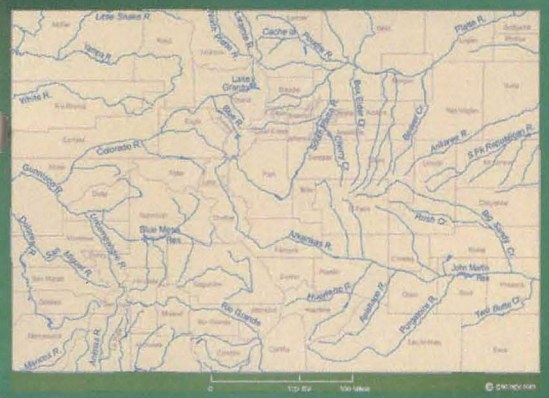
Available research: none found

My 'best guess':

- Exotics may become a problem after fire in aspen stands– they are ideal habitat!
- However, if there is prolific sprouting (from aspen and other understory species), exotic invasions may be minimized
- Recall that MVNP woodlands (no sprouting) were heavily invaded while shrublands (sprouting) were less so.



Riparian areas



Fire regime: Similar to adjacent uplands, though generally less frequent and severe.

Riparian areas are often heavily invaded because of high resource availability- water, nutrients

Riparian areas

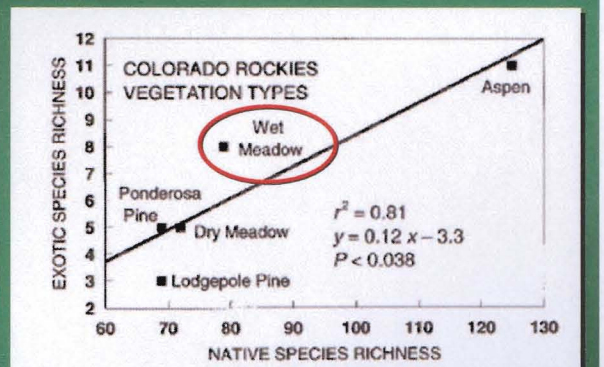


FIG. 7. Relationship of native species richness to number of exotic species at vegetation-type and biome scales (based on combined species lists from 1000-m² plots).

Stohlgren et al. 2003. Ecol Mono 69: 25-46

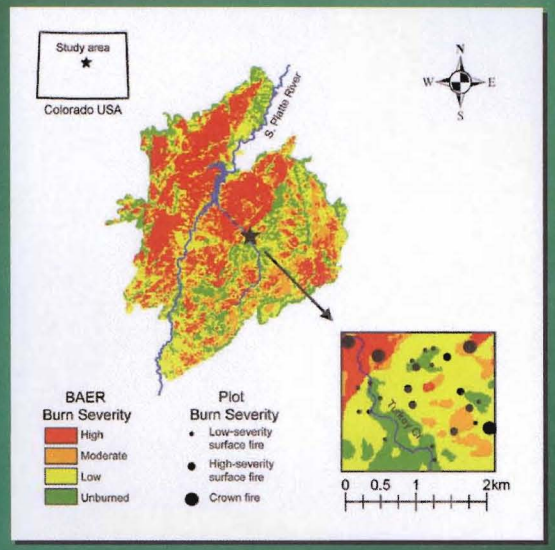
Riparian areas

Available research:

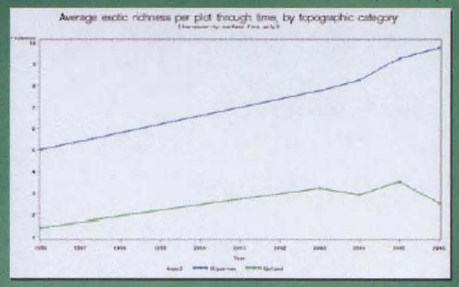
Exotic species establishment after the 2002 Hayman Fire
(Fornwalt et al. In preparation.)

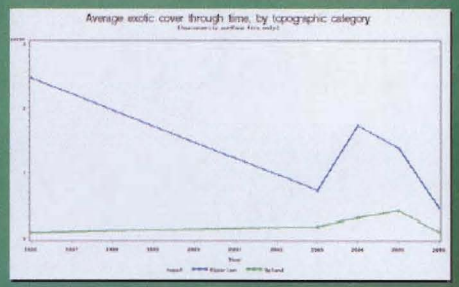
Tamarix sp.(FEIS online database: www.fs.fed.us/database/feis)

Exotic species establishment after the 2002 Hayman Fire (Fornwalt et al in prep)



Exotic species establishment after the 2002 Hayman Fire (Fornwalt et al in prep)



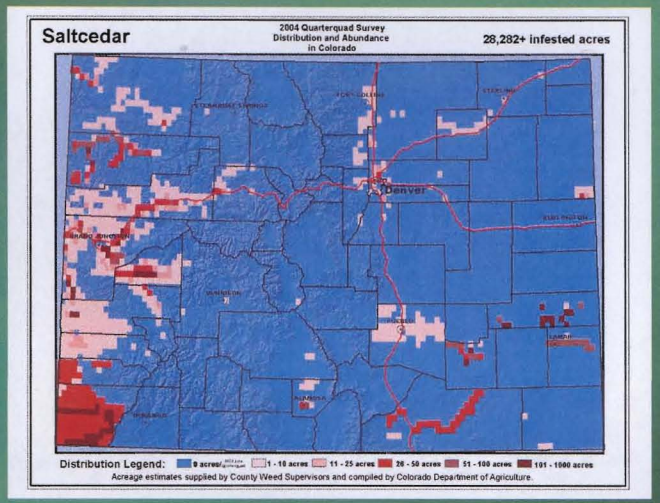


Exotic species establishment after the 2002 Hayman Fire (Fornwalt et al in prep)

Species	1996	2003	2004	2005	2006
Arabis glabra	<0.1			<0.1	
Arabis hirsuta			<0.1	<0.1	<0.1
Axyris amaranthoides		<0.1	<0.1		
Bromus inermis	0.4	<0.1	0.1	0.3	<0.1
Camelina microcarpa		0.1	<0.1		
Carduus nutans	<0.1		0.4	0.1	<0.1
Cirsium arvense	0.2	0.1	<0.1	0.1	0.1
Conyza canadensis		<0.1	0.1	0.1	<0.1
Dactylis glomerata		<0.1			
Descurainia sophia				<0.1	<0.1
Kochia scoparia	<0.1				
Lactuca serriola		<0.1	0.1	<0.1	<0.1
Linaria vulgaris	0.1	<0.1	0.2	<0.1	0.2
Poa pratensis	1.2	0.3	0.2	0.7	0.1
Polygonum convolvulus		<0.1			
Potentilla norvegica				<0.1	
Taraxacum officinale	0.3	0.1	0.2	0.1	0.1
Tragopogon dubius	<0.1	0.1	<0.1	<0.1	<0.1
Triticosecale rimpaui		0.1	<0.1	<0.1	
Verbascum thapsus	0.3	0.1	0.5	0.1	0.1

Tamarix sp. (FEIS)

- In CO, Tamarisk has invaded riparian areas, especially in shrublands, grasslands, and PJ forests

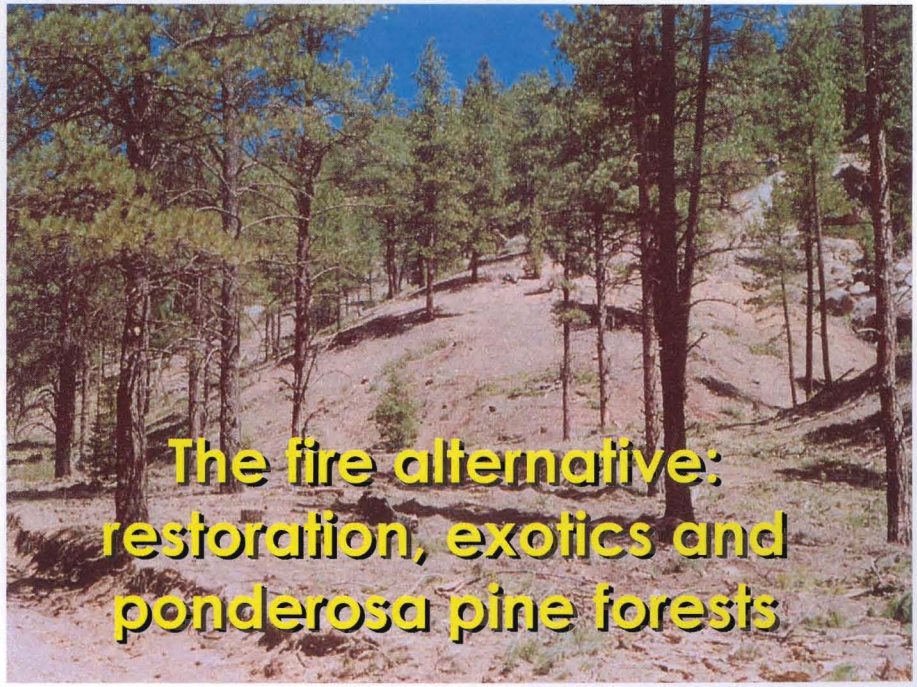


Tamarix sp. (FEIS)

- Tamarisk may promote more frequent and severe wildfires in riparian areas
- Increases in fire size and frequency are attributed in part to increased abundance of fuels

Tamarix sp. (FEIS)

- Tamarisk may be better adapted to the postfire environment than native species, especially on dammed rivers
- Tamarisk is likely to persist following fire and expand its dominance with repeated burning of low-elevation riparian plant communities



Restoration v. fuel treatment goals

Depends on the historical fire regime

Ecological restoration		Fuel treatments
Surface fire regime (PP)		
• Thin from below	→	• Thin from below
• Frequent prescribed fire	→	• Frequent prescribed fire
Mixed-severity fire regime (PP)		
• Thin & restore patchiness	→	• Thin & restore patchiness
• Infrequent prescribed fire	→	• Infrequent prescribed fire
Crown fire regime (generally not PP)		
• Clearcut	→	• Clearcut
• Leave alone		• Thin

Upper South Platte Watershed Protection and Restoration Project

After a largely fire-free century in the SPB, there has been a recent rash of large and intense fires

1996 — Buffalo Creek (12,000 ac)

2000 — Hi Meadow (11,000 ac)

2002 — Schoonover (4000 ac)

Snaking (3000 ac)

Hayman (138,000 ac)

Upper South Platte Watershed Protection and Restoration Project

There has also been a recent rash of forest restoration treatments

1996 — talk of restoration began

2001 — go-ahead to restore17,400 ac of FS land

2002 — first tree cut on FS land, at Trumbull

2006 — ~80% of the 17,400 ac restored

Upper South Platte Watershed Protection and Restoration Project

- To improve landscape condition:
  - Create openings (15-25 % or more of area)
  - Sharply reduce forest density, especially the smaller trees
  - Reduce the amount of Douglas-fir
  - Maintain and restore old growth
  - Use prescribed fire to limit new ingrowth

What is the effect of restoration on exotics?

Restored site

- Trumbull- 1500 ac site
- Treatment occurred in 2002
- Variety of treatments used
  - Mulching
  - Thinning
  - Pile burning

Undisturbed sites

- Located within areas that were not disturbed for at least the last 5 years
- Not 'pristine' or 'unmanaged' forests
- 'Everyday Joe' condition that serve as a point of reference

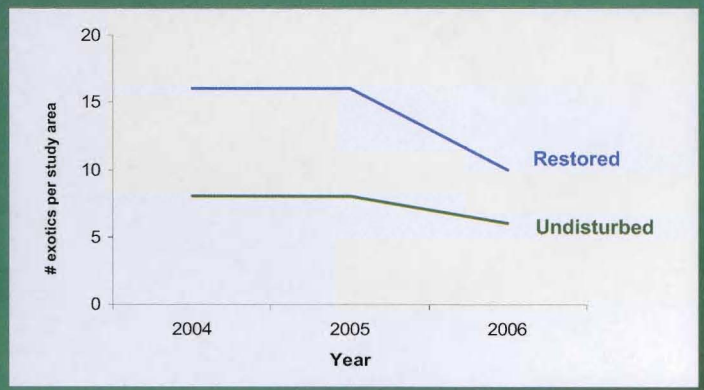
Findings: 26 exotics

26 of the ~200 vascular plant species were exotic

Agropyron cristatum (crested wheatgrass)
Amaranthus retroflexus (redroot amaranth)
Arabis glabra (tower rockcress)
Bromus inermis (smooth brome)
Bromus tectorum (cheatgrass)
Carduus nutans (nodding plumeless thistle)
Centaurea diffusa (white knapweed)
Cirsium arvense (Canadian thistle)
Conyza canadensis (Canadian horseweed)
Hordeum vulgare (common barley)
Lactuca serriola (prickly lettuce)
Linaria dalmatica (dalmatian toadflax)
Linaria vulgaris (butter and eggs)
Melilotus officinalis (yellow sweetclover)
Nepeta cataria (catnip)
Poa compressa (Canada bluegrass)
Poa pratensis (Kentucky bluegrass)
Salsola tragus (prickly Russian thistle)
Sisymbrium altissimum (tall tumblemustard)
Sonchus asper (spiny sowthistle)
Taraxacum officinale (common dandelion)
Tanacetum vulgare (common tansy)
Tragopogon dubius (yellow salsify)
Trifolium repens (white clover)
Tricosecale rimpauii (triticale)
Verbascum thapsus (common mullein)

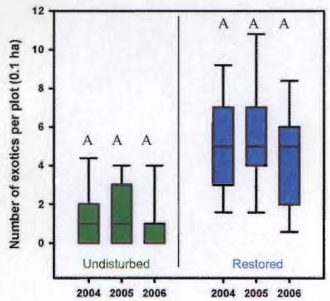
Findings

Exotic species in study sites



Findings

Exotic species richness per plot

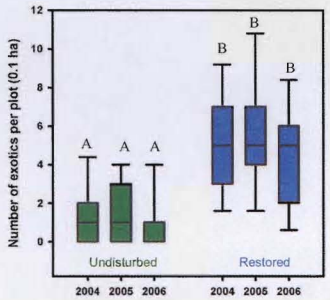


2 types of comparisons:

- Within a site for all years

Findings

Exotic species richness per plot

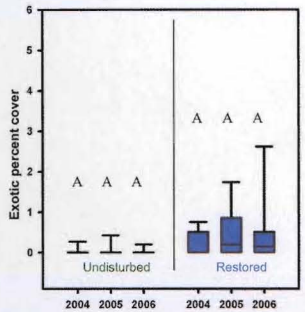


2 types of comparisons:

- Within a site for all years
- Within a year for all sites

Findings

Exotic percent cover per plot

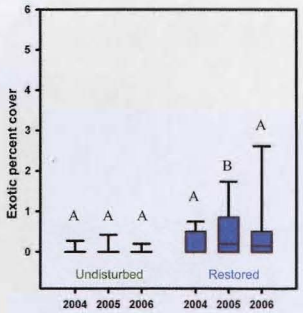


2 types of comparisons:

- Within a site for all years

Findings

Exotic percent cover per plot



2 types of comparisons:

- Within a site for all years
- Within a year for all sites

Findings

The six most common individual exotics:

******Cirsium arvense*** (Canadian thistle)

Conyza canadensis (Canadian horesweed)

Lactuca serriola (prickly lettuce)

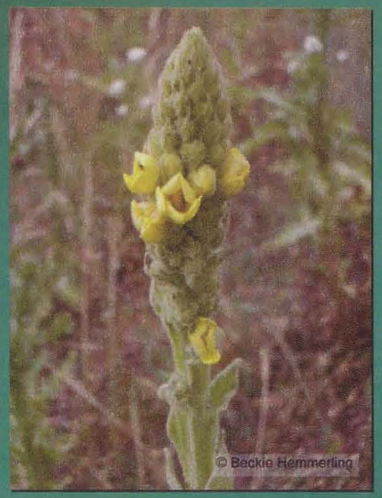
******Linaria vulgaris*** (butter and eggs)

Taraxacum officinale (common dandelion)

******Verbascum thapsus*** (common mullein)

*** noxious in Colorado

Findings



None of the most common individual exotics appeared to be affected by the restoration treatment for any year, except *Verbascum thapsus*.

2004: not stimulated by the restoration treatment

2005: stimulated

2006: stimulated

Findings

Predicting exotic richness

Year
Native % cover
Number natives
% litter cover
% soil cover
% wood cover
Degrees from south
Slope
Elevation
Tree density
Basal area
% mortality (tree density)
% mortality (BA)

Findings

Predicting exotic richness at undisturbed sites

Variable	Correlation
1. **Native % cover**	+
2. **Number natives**	+
3. % litter cover	-
4. % soil cover	-
5. Elevation	-
6. Year	-
7. Degrees from south	-
8. Basal area	+

Findings

Predicting number of exotics at restored sites

Variable	Correlation
1. **% wood cover**	+
2. **% soil cover**	-
3. % Mortality (tree density)	+

Take-home message

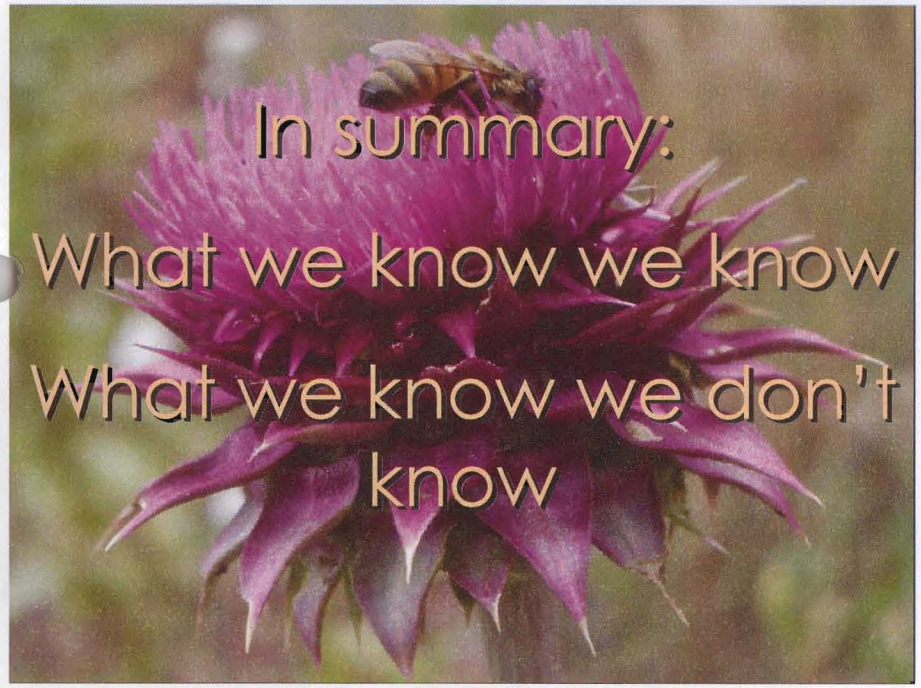
Preliminary results indicate:

- The number and cover of exotics was low for all sites
- However, the restoration treatments increased the number of exotics relative to the surrounding undisturbed forest
- The restored area only had a higher cover of exotics for one year

Take-home message

Preliminary results indicate:

- The number of exotics does not appear to be tapering off four years after the disturbance
- Of the six most common exotics, only mullein was stimulated by the restoration
- Regression modeling indicates that disturbance intensity is probably important in determining the intensity of invasions at restored sites



What we know we know

- We know that fires will continue to burn in Colorado and that exotics will remain a threat to the recovery of burned areas
- The level of threat may be related to elevation:
  - Exotics seem to pose the biggest threat in low elevation sites
  - High elevation sites seem less invaded, with riparian areas and aspen stands at the greatest risk for invasion after fire- though productive areas are an exception

What we know we know

- Exotics are found in systems that vary in their current and historical fire regime-
  - Surface fires (Ponderosa pine)
  - Mixed-severity fires (Ponderosa-dominated)
  - Crown fires (Pinyon- Juniper, grasslands, shrublands)
- In some systems, exotics (esp. cheatgrass) are altering the fire regime and favoring their persistence over the native vegetation

What we know we don't know

- Our understanding of the interaction between fire and exotics in Colorado's systems is far from clear
- More work is especially needed in the higher-elevation forests— unfortunately, fires there are very infrequent, so it will be difficult to study!

Questions?