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Evaluation of the Black Bear Supplemental Feeding Program in Western Washington, USA

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Summary

The Washington Forest Protection Association (WFPA) is an umbrella organization of the forest products industry in Olympia, Washington, USA. The Animal Damage Control Program (ADCP), one of WFPA's branches, developed the black bear (*Ursus americanus*) spring supplemental feeding program in 1986. I field tested and evaluated this unique non-lethal approach to protect conifers from girdling by bears (Flowers 1988) from 1998 to 2002. In this paper I summarized research which determined the efficacy, cost effectiveness and ecological impacts of the supplemental feeding program as a damage control tool.

Foresters in western Washington recognized already early on that one black bear may girdle 60–70 coniferous trees in a day during the spring months. Tree-bark peeling and subsequent foraging on sapwood can result in substantial economic losses for forest landowners. I studied the efficacy of the supplemental feeding program on the Olympic Peninsula. Fourteen conifer stands of approximately 20 ha each were selected. Mean pretreatment conifer damage on these sites in 1998 was 26%. In March 1999, 14,000 trees were marked in these 14 stands. Each stand had 4 transects with 250 marked trees, totaling 1,000 trees per stand. Two feeding stations were installed on each of 7 randomly chosen stands in April of 1999, while no supplemental feed was supplied on the remaining 7 control stands. The ADCP found that bears damaged significantly more trees on control sites than on treatment sites. To validate initial results, feeding stations from 2 of the 7 feeding sites were removed in July 2000. Damage increased by a factor of 7 on one feeding site over the next 2 years. I concluded that the supplemental bear feeding program constituted a viable, non-lethal damage control tool.

I analyzed the costs of the supplemental feeding program in comparison to the costs of accepting bear tree damage in 2004. One Douglas-fir (Pseudotsuga menziesii) stand with known yield data served as a model. I assumed 15, 25, and 35% tree damage by bears in this stand at age 15 and allowed the stand to grow to 35-, 40-, and 45-year rotations. Present value (PV) calculations were performed for the costs of the feeding program to determine if it was the best expenditure for the forest products industry in comparison. For the sensitivity analysis I used 5, 6, and 7% interest rates and found that the costs of feeding bears for 2.5 months annually were always lower than the costs of accepting tree damage by bears. Therefore I concluded that the supplemental feeding program was a cost-effective damage control tool.

I summarized cooperative research to determine if the spring supplemental bear feeding program had impacts of concern on the ecology of western Washington. My review included behavioral characteristics of bears on feeding stations, diet and weight gain among bears, the reproductive success and population density of bears, the home range size of bears, and bear/human conflicts. Motion sensor activated cameras at feeding stations showed little antagonistic behavior among bears. Bears at feeding stations gained weight faster then bears without access to pellets but weight gain was not maintained into the winter dens. Supplemental feeding did not influence the bear’s reproductive success but adult females, yearlings and cubs visited feeding stations over many years. Bears with home ranges outside feeding areas were not attracted to feeding stations. The bears’ home range sizes were not changed by the feeding program. Feeding personnel reported no conflicts with bears around feeding stations. I concluded that the black bear supplemental feeding program, as currently used on private lands, had no undesired ecological consequences.

Zusammenfassung

Die Schwarzbärpopulationen *(Ursus americanus)* im US Staat Waschington werden von Biologen des Washington State Department of Fish and Wildlife (WDFW) auf 25.000 bis 50.000 Tiere geschätzt. Bärschälschäden an Koniferen sind westlich der Cascaden ein grosses ökonomisches Problem für alle Waldbesitzer. Douglasien *(Pseudotsuga menziesii)*, werden von den Schwarzbären bevorzugt geschält, Schäden werden aber auch an Western Hemlock *(Tsuga heterophylla)* und Western Redcedar *(Thuja plicata)* beobachtet. Besonders anfällig sind durchforstete, leistungsstarke 15 bis 25 jährige Bestände mit einer Dichte von etwa 1000 Douglasien pro Hektar. Die Washington Forest Protection Association (WFPA), ein Verband der Holzindustrie im US Staat Waschington, arbeitet daran Wildschäden in Zusammenarbeit mit dem WDFW zu vermindern. WFPA vertritt ungefähr 1.8 Millionen Hektar Wald, von dem 400.000 Hektar anfällig für Bärschälschäden sind.

Mitte März kommen Schwarzbären aus ihren Winterlagern und finden ein nur geringes, natürliches Nahrungsangebot. Gräser, Farne, Moose und Wildkräuter werden aufgenommen, welche aber nur wenig Nährwert für die Bären haben. Hochwertigere Nahrung wird gesucht und mit zunehmender Photosynthese-Leistung der Koniferenbestände auch gefunden. Mitte April beginnen Bären auf ihrer Nahrungssuche Bäume zu entrinden. Dabei wird etwa 1 Meter über dem Boden in die Rinde gebissen, welche dann mit den Klauen schnell entfernt wird, um das zuckerhaltige Phloem zu fressen. Kimball beschrieb 1998, dass das Phloem von Douglasien im Mai/Juni einen aufgelösten Zuckergehalt von bis zu 3.5% Frischgewicht hat. Dies ist ein starker Anreiz für Bären das Phloem von Koniferen

bevorzugt zu fressen, da alternative Nahrung noch weniger attraktiv ist. Das Schälen der Bäume hört mit dem Erscheinen der ersten reifen Waldbeeren, wie Salmonberry *(Rubus spectabilis),* Ende Juni, sofort auf.

Schwarzbärschälschäden wurden seit Beginn intensiver Waldnutzung in gefährdeten Beständen mit dem freien Abschuss von Bären zu bewältigen versucht. Diese Methode war nur selten erfolgreich, denn Bärschäden konnten, gesamt gesehen, nur wenig reduziert werden. Um 1980 akzeptierten die Bevölkerung und Politiker in Waschington es nicht mehr, dass Bären getötet wurden, um Bäume zu retten. Vertreter der Holzindustrie erkannten die Notwendigkeit, alternative Methoden zum Bärenabschuss zu entwickeln. Ralph Flowers, damaliger Leiter des WFPA Animal Damage Control Programmes (ADCP), begann 1986 mit dem Zusatzfütterungsprogramm für Bären zu experimentieren. Vier Jahre später war das Fütterungsprogramm ein kleiner, aber dennoch fester Teil des WFPA Wildschadensprogrammes.

Nach einigen Jahren der Felderfahrung, testete und bewertete ich das Zusatzfütterungsprogramm von 1998 bis 2002 mit wissenschaftlichen Methoden. In dieser Arbeit fasse ich diese Untersuchungen zusammen und beschreibe die Wirksamkeit, Kostenvorteile und die ökologischen Einwirkungen des Zusatzfütterungsprogrammes.

Die Wirksamkeit des Zusatzfütterungsprogrammes untersuchte ich auf der Olympic Peninsula im Westen des Staates Waschingtons. Für die Studie wählte ich 14 Koniferenbestände von ungefähr 20 Hektar aus. Der durchschnittliche

Bärschälschaden in diesen Beständen in 1998 war 26%. Im März 1999 markierte ich 14000 Koniferen in diesen 14 Beständen. Jeder Bestand hatte 4 Transekten mit je 250 markierten Bäumen, insgesamt 1000 Koniferen pro Stand. Zwei Fütterungsstellen wurden im April 1999 in 7 der zufällig gewählten Bestände aufgestellt, während die anderen 7 Bestände als Kontrolle dienten. Die Analyse der Datenaufnahme zeigte, dass die markierten Koniferen der Kontrollbestände wesentlich mehr Schälschäden aufwiesen als die Bestände mit der Zusatzfütterung. Um einen eindeutigen Zusammenhang zwischen Fütterung und Schälschäden herzustellen, entfernte ich 2 der 7 Fütterungen im Juli 2000. Innerhalb der nächsten 2 Jahre häuften sich Bärschälschäden um den Faktor 7 in den 2 Beständen mit entfernten Fütterungsstellen. Aus dieser Erfahrung zog ich den Schluss, dass das Bär-zusatzfütterungsprogramm westlich des Cascadengebirges eine wirksame und wichtige Wildschadenverhütungsmethode für die Holzindustrie in Waschington sein kann.

In 2004 analysierte ich die Kosten des Zusatzfütterungsprogrammes und verglich diese mit den Kosten der Bärschälschäden. Ein Douglasienbestand mit bekannten Wuchswerten diente als Modell. Ich nahm 15, 25 und 35% Bärschälschäden in diesem Bestand im Alter von 15 Jahren an und lies diesen Bestand bis zur Endnutzung mit 35-, 40- und 45 Jahren wachsen. Ich benutzte 5, 6 und 7% für die Sensibilitätsanalyse, um festzustellen, ob das 2 bis 3 Monate anhaltende Zusatzfütterungsprogramm unter allen Umständen die billigere Alternative zum Bärschälschaden ist. Das Ergebnis der Analyse zeigte, dass das Zusatzfütterungsprogramm in allen Fällen billiger war als der Schälschaden.

Im Herbst 2006 begann ich zu untersuchen, ob das Zusatzfütterungsprogramm ökologische Besorgnis rechtfertigt. Ich konzentrierte mich dabei auf das Verhalten von Bären an Fütterungsstellen, auf die Nahrungsaufnahme und Gewichtzunahme, dem Fortpflanzungserfolg und die damit verbundene Populationsdichte, die "home range size" von Bären und welche gefährlichen Konflikte mit Menschen durch Futterstellen entstehen könnten. Mit feststationierten Videokameras, die auf Bewegung reagierten, konnte nachgewiesen werden, dass das antagonistische Verhalten der Bären an den Fütterungen nur gering war. Bären, die Zugang zu den Fütterungen hatten, nahmen anfangs schneller an Gewicht zu, als Bären ohne Zusatzfütterung. Diese verloren den Vorteil aber wieder bevor sie in ihr Winterlager gingen. Am Ende des Jahres hatten alle Bären so viel Gewicht zugenommen, dass sie durch den Winter kamen. Das Zusatzfütterungsprogramm beeinflusste den Fortpflanzungserfolg der Bären nicht, trotzdem erhöhte sich der Populationsdruck um die Fütterungen. Der Grund dafür war, dass Muttertiere ihre Jungtiere zu den Fütterungen führten und diese, nach weiteren 2 bis 3 Jahren, ebenfalls ihre Jungtiere zu den Fütterungen leiteten. Das Bäreneinzugsgebiet wurde von den Fütterungen nicht über das ganze Jahr hinweg beeinflusst. Das ADCP Fütterungspersonal hatte über 20 Jahre hinweg keinerlei Konflikte mit Bären an Fütterungen. Ich zog wiederum den Schluss, dass das Zusatzfütterungsprogramm der Waschingtoner Holzindustrie keine besorgniserregenden ökologischen Einwirkungen hat.

1 Introduction

1.1 Statement of problem

Black bears *(Ursus americanus*) are found throughout most of North America (Tirhi 1996). Populations in Washington State are estimated by the Washington State Department of Fish and Wildlife (WDFW) at 25,000 to 50,000 bears (Tirhi 1996). About 400,000 hectares of second growth 15 to 25-year-old coniferous forests are vulnerable to the black bears' bark girdling behavior (Schmidt and Gourley 1992, Mitchell 2001). Tree damage is most intensive in high yield forests of western Washington, little damage occurs east of the Cascade Mountains (Fig. 1.3). Black bears peel the outer bark of conifers with their teeth and claws to feed on the underlying phloem (Fig. 1.1 and 1.2).

Fig. 1.1: Fresh Black Bear Damage on 22 year-old Douglas-fir. Photo: Ziegltrum

Fig. 1.2: Black bear incisor tooth marks on Douglas-fir phloem. Photo: Ziegltrum

The Washington Forest Protection Association's (WFPA) Animal Damage Control Program (ADCP) counted frequently as many as 70 peeled trees in one day by one bear (Schmidt and Gourley 1992, Ziegltrum 1994). One hectare of forest can be destroyed by a sow and her yearling within 2-3 weeks (Ziegltrum and Nolte 1996). Reforestations of 20 hectares and more were completely girdled in six years (Ziegltrum 1994). The greatest damage is received in Douglas-fir (*Pseudotsuga menziesii*) stands but coastal hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*) are girdled as well. Pre-commercially thinned and fertilized stands of 1,000 trees per hectare are most vulnerable. Silvicultural treatments often initiate the bears foraging behavior since these stands have overall high photosynthesis rates, resulting in up to 3.5% soluble sugars on a fresh weight basis in the phloem (Kimball et al. 1998).

The United States Department of Agriculture, Animal and Plant Health Inspection Service (USDA/APHIS) investigated black bear tree damage on federal lands and described the problem as extremely detrimental to the health of forests and their economic values. The bears' tree damage was estimated at millions of dollars annually (Nolte and Dykzeul 2002). Dead trees on federal or private lands lost their commercial value completely but provided ecological benefits to cavity nesting birds and other snag dependant wildlife species (Brown 1985). Partial debarked trees provide avenues for insect and fungus infestation and may add to the snag distribution in Washington (Raphael 1980).

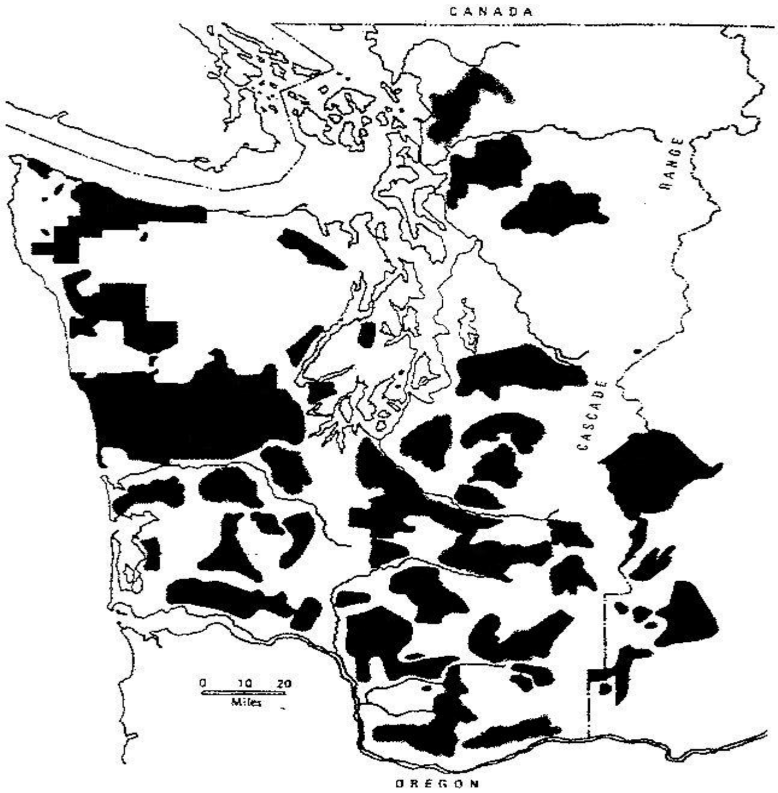

Fig. 1.3: Black bear damage areas in western Washington (Ziegltrum 2005)

Bears in western Washington usually emerge from their winter dens by mid-March (Poelker and Hartwell 1973). Palatable foods with high digestibility are unavailable at this time until the natural berries crop is ready by the end of June (Partridge et al. 2000). Mostly grasses along creeks, skunk cabbage *(Lysichitum americanum*), ferns and mosses are eaten the first 4 weeks. Douglas-firs, west of the Cascade Mountains, start heavily photosynthesizing by the mid of April. The sugar content in the phloem is becoming a strong incentive for bears to feed on the phloem with the beginning of the trees' bud burst. There are little other food sources available in comparison at this time (Partridge et al. 2001).

Damage intensified with modern, high yield forest management practices such as selection of superior seedlings, fertilization, and pre-commercial and commercial thinning operations. Little damage was recognized in old growth forests. Concentrated damage within one tree stand is generally caused by sows with cubs or yearlings since the sows' home ranges average five square miles. Boars often have home ranges of 25 or more square miles and their damage is wider spread and less obvious. Bears peel the most vigorous trees in the most productive tree stands. The phloem is then scraped off with the incisors in a vertical motion. Marks of the incisors are clearly visible on the remaining xylem. Teeth marks, in addition to other findings such as foot prints, claw marks, scats and sightings, allow conclusions about the bears' social status (sow with cubs, yearling, adult male), age and gender.

1.2 Overall objective

The Washington black bear supplemental feeding program during the spring caused international interest. Requests for information on the black bear tree damage management strategies came from many areas of North America but also from Europe and Asia. The knowledge gained through five years of field research shall benefit particularly resource managers in our state. The ADCP goal is to manage black bear damage in an ethical, effective, publicly acceptable and economically viable way. The objective is to minimize black bear damage to forests, not to kill bears. I hope that the information provided will influence the managers' decision making processes and further increase their ability to find a balance between the health of forests in our state and viable black bear populations. Foresters and biologists from all stakeholder groups may find ways for collaboration to benefit the sustainability of all resources. The supplemental black bear spring feeding program may contribute to reach this objective.

My first publication within these three research papers “Efficacy of Black Bear Supplemental Feeding to Reduce Conifer Damage in Western Washington” shall convince forest managers that the black bear spring supplemental feeding program is a viable and effective non-lethal tree damage management tool with great public and agency support. The second publication “Cost Effectiveness of the Black Bear Supplemental Feeding Program in Western Washington” shall show that the program is beneficial to the budget and that the costs of the non-lethal approach holds up to the forces of supply and demand. The third paper “Impacts of the Black Bear Supplemental Feeding Program on the Ecology in Western Washington” may convince both biologists and foresters that feeding bears for 2 1/2 months does not unacceptably impact Washington’s ecology, that it saves trees and bears, and that it does not harm forest management objectives over time.

2 The North American Black Bear

2.1 Systematic

The North American black bear belongs to the Kingdom Animalia, the Phylum Chordate, the Subphylum Vertebrata, the Class Mammalia and the Order Carnivora (Poelker and Hartwell 1973). All species in the Family Ursidae have the ability to cross bread and several combinations have actually occurred (Erdbrink 1953). Black bears have the same genus as Grizzly bears *(Ursus arctos horribili*s) and Polar bears *(Ursus maritimus)*. Two subspecies of black bears are recognized in Washington, the *Ursus americanus altifrontalis* in western Washington and the *Ursus americanus cinnamomum* in eastern Washington. Black bears are unique to the North American continent.

There are eight remaining species of bears worldwide. In addition to the American Black bear, the Grizzly or Brown bear and the Polar bear, we recognize the Asiatic black bear *(Ursus thibetanus)*, Giant Panda *(Ailuropoda melanoleuca)*, Sloth bear *(Melursus ursinus)*, Spectacled bear *(Tremarctos omatus)* and the Sun bear *(Helarctos malayanus)*. Paleontological evidence, based on morphological comparisons and fossil records, suggests that the Ursidae group is of quite recent origin, first dated to the lower Miocene, over 20 million years ago (Simpson 1945). Molecular research supports the findings of paleontologists and is in agreement with the general timing of speciation of bears. Comparison of the genetic mitochondrial DNA among bears revealed a high degree of sequence similarity. The development of genetic differences among bear populations were probably triggered through geographic isolation which caused reproductive and behavioral isolations.

2.2 Distribution and populations

Black bears are common throughout North America, including the mountainous Pacific coastal areas down to California, the Rocky Mountains, the Appalachians to northern Georgia, and forested habitats in Florida and the Gulf Coast states (Fig. 2.2.1). An expanding population is located in Arkansas as well as on barren grounds east and west of the Hudson Bay. The Alaskan and Canadian tundras are new distribution expansions for the black bear. Jonkel and Miller (1970) suggest that this may be in response to the decline of the grizzly bear which is more vulnerable to habitat loss and habitat fragmentation than the American black bear (Wiegand 1998). Grizzlies are known to compete with black bears for habitat and food but also prey upon them. The black bear is very adaptable and expands quickly into areas where the grizzly was exterminated. Black bears in California expanded their range towards the coast over the last 30 years (California Department of Fish and Game 1992). Habitat corridors allow black bears to interact over large geographic areas. Future fragmentation and genetic isolation continues to be a matter of concern for biologists.

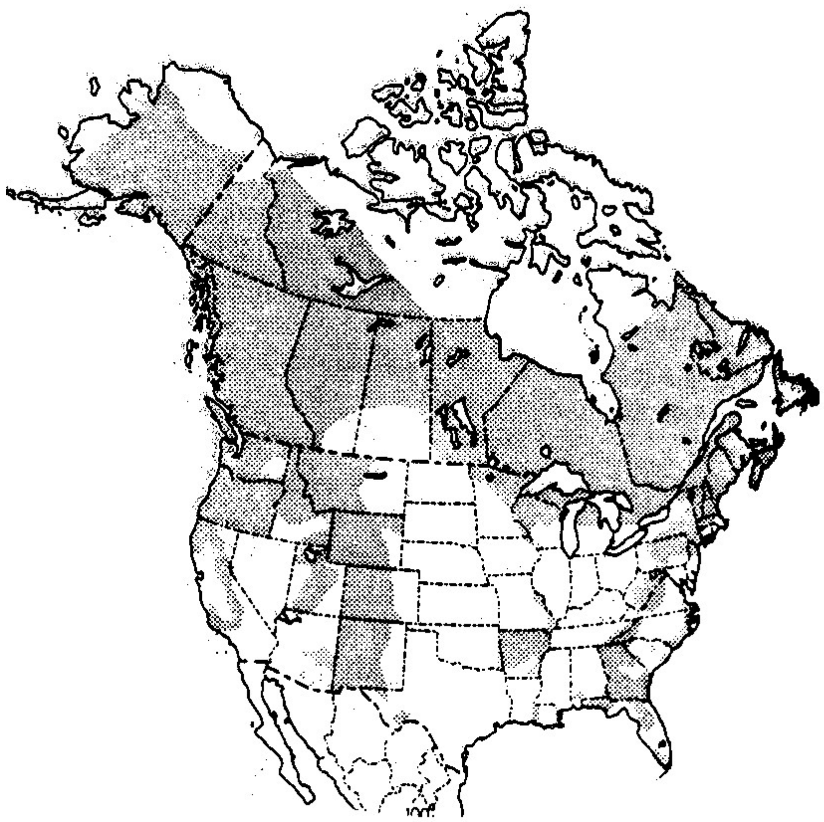

Fig. 2.2.1: Distribution of the black bear in North America (Pelton 1982)

Black bears in Washington are found throughout all forested areas (Poelker and Hartwell 1973) and land where trees were temporarily removed because of timber harvest, fire, or other events such as the eruption of Mount St. Helens in 1980.

Ursus americanus cinnamomum inhabits the east slope of the Cascades, northeastern Washington, and the Blue Mountains (Fig. 3.1). . A large population is found in the Selkirk Mountain range, probably because of very little human habitation. Shrub-steppes in Kittitas and Yakima Counties are the only areas in Washington not considered suitable black bear habitat (Thiri 1996).

The WDFW evaluated the black bear population in Washington as slowly increasing since 1988 (Thiri 1996). Koehler (1994) reported densities of 1.6 bears per square mile south and east of the Quinault Indian Reservation.

2.3 Life history

The peak of the breeding season in western Washington extends generally from mid-June to mid-July but may occur anytime later in the year before winter denning (Jonkel and Cowan 1971). At this time, mature follicles are present in the ovaries of sows and spermatogenic activity is present in boars. Sexual maturity in females is reached at age 4 1/2 and males at age 5 – 6 (Poelker and Hartwell 1973). Lactating females do not develop mature follicles, nor do they exhibit estrus or accept males during the breeding season. Alternate year pregnancies are therefore normal. Interruption of lactation, even for the short period of two days after cubs were lost, may initiate estrus and allow consecutive year pregnancies. Gestation is approximately 220 days but can range from 90 to 260 days, depending on time of fertilization. Following fertilization, the embryo develops to a blastocyst stage were development is arrested and implantation deferred (delayed egg implantation) until the beginning of December. The sow gives birth to 2 to 4 cubs in the winter den by late January or early February (Rogers 1999). Sows with cubs emerge from their winter dens in mid-March.

3 History of the WFPA and the ADCP

The Washington Forest Protection Association (WFPA) is a trade association of the forest products industry in Washington State, representing the owners of 1.8 million hectares of private forestlands. The association's goal is to advance sustainable forestry to provide forest products and environmental benefits for the public. WFPA establishes balanced forest policies that encourage investments in forest lands, protects wildlife, fish, water, and promotes responsible forest management as a preferred land use.

The Animal Damage Control Program (ADCP) is a program within the WFPA. The ADCP supervisor manages wildlife damage to forests in cooperation with the Washington State Department of Fish and Wildlife (WDFW) in an effective, ethical and economically viable manner.

3.1 The Washington Forest Protection Association (WFPA)

On April 10, 1908, 22 timber companies organized the Washington Forest Fire Association (WFFA), which fielded the first professional fire patrol system in the state. Gorge S. Long, Resident Agent and General Manager of the Weyerhaeuser Timber Company from 1900 to 1929, was instrumental in organizing the WFFA. Members of the new Association elected Long as the first President. Under his leadership, the WFFA produced a budget and paid for a force of men to detect and battle fires on forest land in western Washington (House 2008). Over the next 50 years, the Association collaborated with state and federal fire suppression programs and embarked on a campaign to change the logging practices that caused most forest fires.

------------ 100km

Fig. 3.1: Washington State: Economically significant black bear damage occurs only west of the Cascade Mountain Range which runs north/south.

Experience with deadly forest fires was severe and economic losses unacceptable. In 1902, the Yacolt Burn killed 38 people and consumed 99,550 ha in Southwest Washington, particularly in Clark, Cowlitz, and Skamania counties. Fires were commonly caused by sparks from steam-powered logging locomotives and machinery, lumber mills, and from burning slash - the debris left after mature trees are cut. When fires broke out, there was no organized effort to put them out and they were allowed to burn uncontrolled. More timber was being destroyed each year in fires than was being harvested (Cowan 1961, WFPA Historical Archive 2008).

In 1903, the State Legislature designated the State Forest Fire Warden as the Commissioner of Public Lands**.** He was assisted by county commissioners who were deputy wardens. Without funding or authority, these officials could do little to protect the 830,000 ha of timber owned by the state. At the next session in 1905, the Legislature established a State Board of Fire Commissioners, which appointed a State Forest Fire Warden and his deputies. The $7,500 appropriated to fight fires for the biennium ran out the first summer. The commission appealed to private timber interests, which owned vast tracts of land, for assistance. A total of $10,300 was raised to fight fires in 1906 (Cowan 1961).

In the spring of 1908, leaders in the timber business mailed 800 letters to timberland owners inviting them to form a voluntary association to suppress forest fires. Twenty-two companies responded and formed the WFFA. That summer, WFFA crews under Chief Fire Warden D.P. Simons patrolled forests and responded to fires. The members assessed themselves $0.012 per ha and collected $21,914.71. The newly formed WFFA managed to recruit a total of 126 members the first year, whose holdings amounted to 1,041,667 ha of timber. The Chief Fire Warden organized a force of 75 men who were equipped with an axe, a planter's hoe, and a 10-quart water bag each. Patrolmen were commissioned by the State as Forest-Rangers-at-Large.

The year 1910 was bad for fires, particularly in King, Pierce, and Lewis counties. The State Fire Warden ran out of appropriated funds before the end of the fire season and the lumbermen of the Association stepped in with $10,000 to keep the state crews in the field. The Legislature was slow to fund efforts at suppression and prevention, but the WFFA instituted a program of camp inspections where patrolmen asked operators to use spark arresters on boiler stacks and to limit burning. Prevention became a major part of the WFFA's program. In order to reduce the number of fires caused by wood-burning equipment, the WFFA advocated a shift to fuel oil which was safer and more economical than wood.

In 1911, the U.S. Forest Service began its forest fire program and partnerships evolved between private, state, and federal officials evolved. Association patrolmen were commissioned state fire wardens who could issue burn permits, supervise burning, and restrict access to fire hazard areas. Fire wardens were empowered to close down logging operations in high-risk areas.

In 1917, the Forest Patrol Law required that timberland owners bear the cost of fire control, which increased membership in the WFFA and spread the cost of patrols and suppression more equitably. That year, the amount of timber lost to fire was about one-third of that harvested. Fire prevention and protection by the Association eventually included lookout towers, aerial patrols, site inspections, and information campaigns. Combating forest pests with aerial spraying of pesticides became part of the WFFA's mission (Fig. 3.2). When required, wardens personally supervised slash burnings for members. In time, loggers, campers, hunters, farmers, and natural forces caused only a few forest wildfires.

Education and information of the USDA Forest Service on “how to prevent forest fires” started to become a successful campaign and the public responded well to the large scale advertisements.

Fig. 3.2: Washington Forest Fire Association crew with truck, equipped to run on railroad tracks, ca. 1920s.
Photo: WFPA

Fig. 3.3: Light tank truck used by Washington Forest Fire Association during World War II.
Photo: WFPA

Forest fires however continued to be a great threat to the WFFA. New fire fighting equipment was purchased between 1920 and 1930 (Fig. 3.3). The WFFA budget in 1957 was $252,951. By 1958 the state and federal forest fire program had evolved to the point that the WFFA was dissolved in favor of the Washington Forest Protection Association (WFPA).

3.2 The Animal Damage Control Program (ADCP)

During the spring of 1959**,** the Washington Forest Protection Association (WFPA) organized a cooperative black bear damage control program in Grays Harbor County among interested landowners. Bear damage had spread already throughout western Washington and was specifically intensive in 15 to 25- year-old Douglas-fir plantations (Fig. 3.2.1). The co-op work started on April 1, 1960 and subsequently an invitation was issued to all forest landowners to join the proposed program. A budget with an assessment rate was decided upon and it was determined to hire two trappers. An article concerning the project was inserted in the press, stating that the program would be conducted at a scale and of a duration that would halt timber damage by bears. In two meetings of the new co-op, the program was adopted and a Board of Trustees was elected.

The co-op hired Bill Hulet and Ralph Flowers. Hulet was retained to work the west half of the Grays Harbor area and Flowers undertook control of the east half, concentrating on the area north of the Chehalis River. Hulet used dogs and snares to control black bear damage, Flowers used snares and "still" hunted (Fig.3.2.2). During the first season Hulet worked seven months and Flowers six. Both trappers were paid a minimal salary plus an allowance for vehicles and dogs. In addition, each man, after taking 50 bears, received a bonus of $25 for every additional animal taken. This incentive assured the co-op that each year the maximum number of bears was captured. During this first control effort in 1960 a combined total of 167 bears were taken (Dick 1985).

**Fig. 3.2.1: Two year old black bear damage in a 20-year old Douglas-fir stand, Capitol Forest, Washington State.
Photo: Ziegltrum**

As a result of this initial success of the cooperative bear control effort, forest landowners requested WFPA to expand damage control efforts to Clark, Cowlitz, Lewis, Wahkiakum, Clallam and Jefferson Counties. Several meetings of interested landowners were called to assess the bear damage and set up the framework for the expanded cooperative organization. On April 5, 1961 two more trappers took to the woods in the newly formed North Olympic Animal Damage Control Branch in Clallam and Jefferson counties. The Southwest Branch of the organization hired one additional trapper on March 1, 1961 and commenced field work. Since this co-op was not within the portion of the state were the bear was classified as a predator, so it was necessary to obtain permission from the State Game Department to remove an animal through damage control. Monthly progress reports of all trappers were sent to the state agency and land managers. In 1961 the North Olympic Branch took 210 bears, the Southwest captured 68 and in Grays Harbor 118 bears were dispatched, totaling 396 animals (Flowers 1984). The objective at this time was to reduce the bear damage by a general reduction of the bear populations (Fig.3.2.2).

Fig. 3.2.2: First attempts of black bear damage control: Still hunting from a vantage point by WFPA hired hunter Ralph Flowers in 1979.
Photo: WFPA

The possibility of finding answers to the bear damage problem through research was first discussed in 1962. One year later, a comprehensive cooperative research program was initiated with a budget of $250,000. Cooperating agencies for the research program were the State Game Department, U.S. Bureau of Sport Fisheries, U.S. Forest Service and the Washington Forest Protection Association's Animal Damage Control Branches. Two state biologists, one biologist hired by forest industry, research foresters and graduate students were utilized to do the research on the ground. WFPA's damage control hunters assisted with the field work and collected field samples. The study was published in 1973 by the Washington State Game Department, titled Black Bear of Washington (Poelker, Hartwell 1973). This work resulted in a significant gain of knowledge and was the basis for better understanding the bears' biology and ecology. The study also suggested minimizing professional bear damage control work through the co-op and shifting lethal control efforts to the sport hound hunting groups in Washington.

In the meantime, a fourth bear co-op, the Central Animal Damage Control Branch was implemented in 1967. Its operations encompassed parts of Lewis, Thurston, Pacific and Pierce counties. The four control branches were individually budgeted, all had a different assessment basis and each had its own executive committee. This unworkable situation was solved in 1972 by consolidation of all animal damage control branches into a unified program which greatly facilitated its administration.

Earlier, at a Game Commission meeting in May 1969, the WFPA presented a statement supporting the Department of Game's recommendation that the bear be declared a game animal in the five Olympic Peninsula counties. With the bear a game animal, it would then be possible to regulate hunting seasons, bag limits and hunting areas. In return, the WFPA asked the Commission to openly recognize the black bear damage problems and the need for damage management. This assurance was indicated. The WFPA also pointed out that if conclusions and management recommendations of the cooperative bear study were correct; the indiscriminate killing of bears by sportsmen had little impact on the occurrence of bear damage. These meeting events changed WFPA's damage management strategies drastically.

As late as 1969, six hunters were employed by the four damage control branches, taking a total of 419 bears that season. It was now anticipated that the number of bears taken annually by WFPA's hunters would decline as hunting areas became more restricted. The co-op's objective was now to manage and control damage rather than kill bears. The bonus bounty was dropped and legitimate salaries were paid to the damage control staff. This made it possible for WFPA's hunters to direct their efforts towards capturing bears in areas where damage was high.

The Washington black bear was declared a game animal in1970. From then on it was necessary to obtain special permits for bear control activities from the Department of Game and this arrangement continues with slight modifications. In order to permit greater participation by the sport hunters in helping solve the bear damage problems, the WFPA, the Washington State Hound Council (Fig. 3.2.3) and the Game Department worked together in 1973 to set up Spring Damage Bear Hunts on a damage unit basis. The resulting proposal was adopted by the Game Commission the same year. The intent of the proposal was to direct sport hunting pressure to critical damage locations at the time damage was occurring. Research findings showed that one bear would be in the same location at the same time, year after year. By hunting only the damage areas the probability of catching the animal which did the damage would be greatly increased. Flowers was responsible for identification of the damage areas and published special hunter's maps each year paid for by the landowners. In 1973, the spring bear hunting season was restricted to 16 bear damage units in 12 counties, compromising 2,520 square miles. This was an 80% reduction of hunting opportunity from April to June of one year earlier. By 1979, the seventh year that the Spring Bear Hunt concept had been in effect, the results were finally gratifying. Sport hunting pressures increased each year and as a consequence, bear damage levels decreased significantly. The Spring Damage Hunts generally diminished in size and number each year and boundaries were changed as damage was controlled or recurred. WFPA conducted an aerial survey of all damage areas in western Washington each summer and monitored closely all reports of fresh damage.

Fig. 3.2.3: Hunting a specific bear with hounds in a damage prone area in western Washington. The black bear climbed up the tree. Photo: Ziegltrum

In the early years of WFPA's damage control program the black bear was looked upon with contempt; it was considered a parasite by an apathetic public. Later, around 1979, a new generation with a new awareness questioned if it was right to kill bears for the benefit of growing trees. Environmentalists, animal rights activists, sportsmen and the media were interested in damage control work and constantly monitored WFPA's operations. The Game Department and sportsmen started to become concerned by an apparent decrease in the bear populations. Nevertheless, by 1984, the 25th season of the Animal Damage Control Service and the 12th year of Spring Bear Damage Hunts, bear damage to young timber stands continued to exist but decreased continuously. This situation allowed WFPA to concentrate on specific damage areas, called "Hot Spots". This concept found support from the Game Department. Sport hunters replaced the professional WFPA hunter over the next couple of years. The co-op's control season was curtailed from a year-round, no limit basis, to a two months designated spring unit hunt. The professional hunting staff was held at one man, who was employed from April 15 through July 15. The "last man" used only hounds during the two month spring season but was often called to follow up on unsuccessful sport permit hunts or served as a damage spotter. Snaring was already held at a minimum and employed only in situations that could not be handled by hound hunting. In 1984 the total harvest of bears during the spring months from sport and professional hunting was 131 bears. The spring bear season continued one more year in nine damage units, comprising 1,004 square miles.

In 1985, the Department of Game voiced concerns about the wisdom of continued spring damage control seasons for black bear. Results of tooth analysis of bears taken by sportsmen and the WFPA hunter in western Washington revealed a high percentage of young bears 4 1/2 years of age. Since bears reach the reproductive age at four years, this signaled a dangerously low present breeding age bear population. This was not only a biological problem but also one for foresters. Even a few bears were capable of inflicting extensive damage to timber resources and therefore there was still a legitimate need for control measures. But it was also apparent that, to maintain a viable bear population, WFPA's methods of population control would be drastically curtailed in the near future and a search for alternative damage control tools began under the leadership of WFPA's Animal Damage Control Service Supervisor Ralph Flowers.

During 1980-81, the U.S. Fish & Wildlife Service and the WFPA under the auspices of the Utah Cooperative Wildlife Research Unit, contracted a study of habitat use by black bears in clear cut forests on Long Island, Washington. One finding of the study showed six female bears, whose home ranges on the island had been documented in an earlier study (1973-74), were still utilizing the same home ranges in 1980-81. This impressed Flowers and further substantiated his belief that adult female black bears and their sub-adult offspring where the segment of the population inflicting the heaviest tree damage. Flowers gift for field observation soon provided industry with some hypotheses, ready to be field tested. Radio collared bears throughout the study spent a lifetime confined to a very limited geographical area. Their male offspring, after becoming adults were less restricted in their home range size and ranged over vast areas, creating scattered damage in their travels.

Considering this new knowledge, Flowers proposed the supplemental bear feeding program in 1984 to the ADCP committee. The feed would meet the nutritional needs of bears in areas of tree damage during the critical months of April to the end of June. WFPA and the Department of Wildlife approved the experiment. Flowers developed a food pellet formula and produced the first pellets in his own, small, food processing mill in Aberdeen. The study was implemented in 1985 on a 21 square mile unit near Kalaloch along the Washington coast. Initial results were impressive. All individual test plots showed improvements, in some cases damage ceased all together. During 1986 the study was continued and expanded to include 800 square miles with test results exceeding expectations. Success was even more encouraging in 1987 when only a few damaged trees were found. As a consequence, many landowners started to use the supplemental feeding program and the concept spread quickly over western Washington and large areas in western Oregon. The public and landowners recognized that it would create a conflict if bear feeding and spring hunting units overlapped. In 1988 the spring bear hunting season was therefore eliminated.

Lethal control was used conservatively to test the efficacy of the non-lethal approach. No bears were harvest in 1989 and only eight bears taken a year later. The Animal Damage Control Program seemed to have shifted from lethal damage control to the non-lethal feeding program (Fig. 3.2.4). Acceptable tree damage, few lethal control activities, great public support and excellent cooperation with the State Department of Wildlife proved the ADCP's strategy right. The euphoria didn't last long. In 1992 the ADCP recognized unacceptable damage in many units where the feeding stations were used. Field observation soon helped to understand the problem. Instead of one or two bears on the initial feeding station, the ADCP observed five or more bears at feeders with damage often close by. This demonstrated that the ADCP did not provide enough supplemental food to serve all bears visiting the feeding stations.

Two feeders instead of one were now generally installed at opposite sites of a tree stand. The bear populations in feeding areas grew quickly and control during the regular hunting season needed to be encouraged. Sport hunters with hounds were drawn randomly by the WDFW since 1973 to harvest bears in high density areas. Unfortunately, it was soon clear that this "lottery system" was ineffective and provided more recreational opportunities to trophy hunters then it controlled damage. In 1995 the lottery system was abolished and replaced by a selection process, used by landowners to have local, competent hunters on their lands. In addition, hound hunters had opportunity to hunt special areas of concern even behind locked gates during the regular bear hunting season.

Fig. 3.2.4: Black bear visiting a feeding station in Snoqualmie, June 2000. Photo: Ziegltrum

In 1995 another black bear damage management problem evolved. Initiative 655 outlawed all recreational hound and bait hunting for bears and cougars in December 1996. Bear sport harvests dropped one year later by nearly 50%. It became necessary to develop a new "Depredation Permit System". The system was implemented in

1997 in cooperation with the Washington State Fish & Wildlife Commission, the Washington State Department of Fish and Wildlife (WDFW) and the ADCP. This system allowed landowners to quickly access permits to respond to damage. Since 1996 spring damage complaints doubled compared to earlier years and lethal control requests increased accordingly. The WDFW recommended a prolonged hunting season for black bear in damage areas in western Washington, increased the bag limit to two bears, decreased the tag fees and successfully encouraged hunter's success.

Twelve forest companies from Oregon and two Indian Nations in Washington joined the Washington ADCP in 1992. In 1998 one forest company from California joined the ADCP. ADCP membership in Washington alone included 39 land owners, representing 1.35 million ha of forest land. The supplemental feeding program was used on about 400,000 ha. Changes to the composition of the pellets needed to be made because of upcoming "Mad Cow Disease" cases in Canada and the United States. After two years of field tests, the protein source of the pellet was changed from beef to chicken protein which satisfied the concerns of the Washington State Department of Agriculture. In addition, the pellets were produced in smaller and hotter dices which made the pellets very dry and improved palatability and shelf life. The supplemental feeding program was now expanded significantly throughout western Washington and its volume doubled for seven years in a row. Today, 20 years after the first field tests, the supplemental feeding program is the ADCP's most used and effective damage control tool. Lethal control became a secondary option (Ziegltrum 2001).

From 1998 to 2005, the ADCP used over 450,000 pounds of pellets annually in 850 feeding stations while other options are being investigated. Cooperative and collaborative research between Washington and Oregon to minimize black bear damage in an effective and publicly acceptable way started in 1996. The Collaborative Research Team (CRT) is represented by the forest products industry in Washington, WFPA, the Oregon Forest Industry Council (OFIC), the United States Department of Agriculture (USDA) Forest Service, Washington State Department of Natural Resources (DNR) and the USDA Animal and Plant Health Inspection Service (APHIS). This working group is looking for long term solutions to animal damage problems through research.

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4 Efficacy of black bear supplemental feeding to reduce conifer damage in western Washington

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Abstract: While searching for food, 1 black bear (*Ursus americanus*) may girdle 60–70 coniferous trees in a day during the spring months in western Washington, USA. Tree-bark peeling and subsequent foraging on sapwood can result in substantial economic losses for forest landowners. The supplemental feeding program, a non-lethal approach to minimize black bear damage by providing an alternative food source, was developed by the Washington Forest Protection Association (WFPA) in 1986. From 1998 to 2002, I studied the efficacy of this supplemental feeding program on the Olympic Peninsula. I selected 14 conifer stands of approximately 20 ha each for study. Mean pretreatment conifer damage on these sites in 1998 was 26% of trees. In March 1999, 1,000 trees were marked on 4 transects throughout each stand. Two feeding stations were installed on each of 7 randomly chosen stands in April of 1999, while no supplemental feed was supplied on the remaining 7 control stands. I found that bears damaged significantly more trees on control sites than on treatment sites ($P < 0.001$). To validate initial results, I removed feeding stations from 2 of the 7 feeding sites in July 2000. Damage increased by a factor of nearly 7 on 1 feeding site over the next 2 years. I concluded that the supplemental bear feeding program constituted a viable, non-lethal damage control tool.

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Key words: black bear, conifer damage, non-lethal damage control, Pacific Northwest, sapwood, supplemental feeding, *Ursus americanus*, Washington Forest Protection Association, Washington state.

4.1 Introduction

The black bear population in Washington State is estimated at 25,000–50,000 animals (Tirhi 1996). A significant segment of the bear population is associated with some 400,000 ha (Mitchell 2001) of 15–25-year-old industrial forests in western Washington. Bear damage to trees has a significant aggregate economic impact across these lands, estimated in millions of dollars annually (Nolte and Dykzeul 2002). The WFPA's Animal Damage Control Program (ADCP) attempts to control black bear damage in Washington State. In addition to lethal black bear control methods, the WFPA developed the supplemental black bear feeding program in 1986 as a potentially non-lethal damage-control alternative (Flowers 1986). I evaluated the efficacy of this feeding program from 1999 to 2002.

Black bears emerge from their winter dens in western Washington around mid-March, and natural foods at this time are limited. By the beginning of May, bears feed on skunk cabbage (*Lysichitum americanum*), false dandelion (*Hypochaeris radicata*), horsetail (*Equisetum arvense*), and cow parsnip (*Heracleum lanatum*; Poelker and Hartwell 1973, Partridge et al. 2000). Tree-bark peeling and subsequent foraging on sapwood (phloem tissue) by bears begin with initiation of tree growth around mid-April in the low elevations of the coastal ranges.

Feeding on newly forming vascular tissue can either kill or seriously damage trees (Poelker and Hartwell 1973). The primary targets of bears are 15–25-year-old stands with about 1,000 trees/ha and trees about 20–40 cm diameter at breast height (dbh). Bears often bite into the lower bole of a tree and then remove the outer bark around all or part of the base of the tree with their claws. The phloem is then removed with the incisor teeth in an up and down motion of the head, leaving clear vertical tooth marks on the xylem (Ziegltrum and Nolte 1996). Complete girdling is lethal to trees, while partial girdling reduces growth rates and provides avenues for subsequent insect and disease infestation. The severity of tree loss is compounded because bears typically select the most vigorous trees within the most productive stands (Kimball et al. 1998*a*). Stands with high growth potential can be entirely lost to bear foraging behavior within 5–6 years (Ziegltrum 1994).

Damage to trees frequently occurs after stand improvements, such as pre-commercial thinning and fertilization, have been implemented and when conifer growth is at its seasonal peak (Mason and Adams 1989, Nelson 1989). In May, the phloem may contain up to 3.5% soluble sugars on a fresh weight basis (Kimball et al. 1998*a*), which provides an incentive for bears to consistently feed on coniferous sapwood from mid-April to the end of June in the absence of similarly attractive food sources. Phloem provides fructose, sucrose, and glucose (Radwan 1969, Kimball et al. 1998*b*). These sugars are immediately available for a bear's energy needs after emergence from the winter den. Bears target western hemlock (*Tsuga heterophylla*), the dominant tree species of the coastal range, about 2 weeks earlier than Douglas-fir (*Pseudotsuga menziesii*) because of an earlier bud break and initiation of growth (personal observation). Damage to trees usually is severe and may result in 60 to 70 peeled trees by a single foraging bear in 1 day (Schmidt and Gourley 1992). Toward the beginning of July, as soon as wild salmonberry (*Rubus spectabilis*) is available, bear foraging on coniferous trees ceases (Ziegltrum and Nolte 1996). Red huckleberry (*Vaccinium parvifolium*), blackberry (*Rubus ursinus*), and elderberry (*Sambucus racemosa*) ripen in August and are the focus of foraging bears throughout the summer and fall months before bears return to their winter dens in November.

Unrestricted, lethal black bear removal by forest managers became less politically acceptable in Washington in the early 1980s, increasing the urgency for the development of non-lethal control methods (Partridge et al. 2000). The supplemental black bear feeding program was developed with the objective of providing an alternative food source to lure bears away from trees during the spring months. The ADCP avoided a year-round bear feeding program to decrease the likelihood of the supplemental feeding program contributing to bear population increase. The assumption was that bear foraging behavior during the rest of the year would not change and that bears will naturally wean off the supplemental food as soon as wild berries ripen in July.

After anecdotal initial success, the supplemental feeding program was quickly implemented in 1989. Demand for bear pellets grew to about 40,000 kg/season within the first 2 years. During 1996–2002, the ADCP distributed between 240 and 250 metric tons from April to June annually through 900 feeding stations established in vulnerable timber stands in western Washington (Ziegltrum 2003).

The carbohydrate concentration of pellets is approximately 25%, which is about 8 times greater than the carbohydrate concentration in Douglas-fir sapwood (Kimball et al. 1998*a*). This high sugar content provides an incentive for bears to consistently feed on the pellets (Partridge et al. 2000). Fats, chicken protein, vitamins, blood concentrates, sugar beet, and minerals added to the pellets enhance palatability and the nutritional balance of the feed (Flowers 1986). The pellets are very hard and have a shelf life of >1 year if stored under cool and dry conditions. The pellets are resistant to crumbling unless they become wet. Anecdotal field observations indicate that bears will not eat powdered, wet, or fermented feed.

My research tested 2 hypotheses: (1) providing bears with this alternative food source reduces damage to coniferous trees in western Washington; and (2) removal of feeding stations increases subsequent damage to trees.

4.2 Study area

I conducted my study on mixed Douglas-fir and hemlock stands on the Olympic Peninsula in Washington State, USA. Eight test sites were located on the north side of the peninsula in Clallam County, along State Route 112, west of the town of Joyce. Six additional test sites were located on the west side of the peninsula along U.S. Route 101, near Kalaloch in Jefferson County. Ten test sites were on land managed by the Washington State Department of Natural Resources. Four sites, in Kalaloch, were located on land managed by the Northwest Forest Resources Timber Company (Rayonier, Washington, USA). All stands had bear activity, but no management efforts to reduce damage had been practiced on any of these sites prior to my study.

Fig. 4.1: Location of 7 bear feeding stations and 7 control sites in Joyce and Kalaloch. (Ziegltrum 2004)

4.3 Methods

4.3.1 Pretreatment survey

I selected 14 research sites in the summer of 1998. I began pretreatment surveys in March 1999 to assess the existing characteristics and damage levels of each stand (Table 1). Tree age on the selected sites varied between 18 and 26 years, which is within the age range considered most vulnerable to bark-peeling by bears. All stands had been pre-commercially thinned prior to the experiment's initiation. Stand

		Treatment		Control	
Year	*n*	$\bar{x}$	SE	$\bar{x}$	SE
1999	7	4.9	4.5	26.1	4.5
2000	7	10.3	4.5	21.6	4.5
2001[a]	5	2.8	5.3	14.8	5.3
2002	5	3.4	5.3	16.0	5.3

[a] Feeders were removed from 2 sites in the summer of 2000.

Table 4.1. Mean number of black bear damaged conifers on 14 sites (n = 7 pairs) with and without supplemental feeding in Clallam and Jefferson counties, Washington, USA, 1999–2002.

sizes were between 16 and 20 ha, with similar timber stocking rates of approximately 1,000 trees/ha of Douglas-fir and western hemlock. Existing bear damage in these stands served as an indicator of bear presence, although bear densities on these sites were unknown.

I divided each stand into 4 sections and extended a 10-m-wide belt transect into the stand perpendicular from the edge, starting at a random location within each quarter. Transect placement was stratified to ensure that transects ranged across different areas of stands. A team of 8 people worked simultaneously in 1 stand. Two surveyors on a given compass line surveyed the first 250 live trees encountered within 1 belt transect and documented existing bear damage. Often, 1 or more of the 4 transects went through large, wet, or rocky areas without any coniferous trees. Therefore, since 250 trees/transect were necessary, transect lengths varied.

Fourteen thousand trees were marked and examined on the 14 sites (1,000 trees/site). Trees with bear damage were marked with red tree paint, and undamaged trees were marked with blue tree paint. Dead trees were excluded from the survey. Annual post-treatment surveys over the next 4 years examined the same 1,000 marked trees on each site.

4.3.2 Post-treatment survey

Stands with similar levels of damage were paired for analysis (n = 7 pairs). I randomly assigned treatment and control within these pairs. Two feeding stations were placed in each of the 7 treatment stands in April 1999 before bears began to forage on tree sapwood. In the first year, beaver (*Castor canadensis*) carcasses were initially hung in the trees next to the feeding stations to lure bears quickly to the supplemental food, and thus minimize initial learning time. Feeding stations were stocked with pellets by the ADCP personnel on a weekly basis throughout the damage period at a rate of 100 kg/feeding station. No other bear damage management control tools were applied on feeding sites or control sites.

Black bear feeding stations were constructed from plastic drums holding about 90 kg of pellets. Two cables, at the top and bottom of the drum, held the feeder tightly attached to a tree. An opening in the front enabled bears to access the pellets inside the feeder. A simple self-replenishing mechanism, in the form of a slanted plywood sheet inside the barrel, restricted bears from playing with the pellets and from spilling excessive amounts of food. Feeding stations were placed near a road, providing easy access for personnel.

The first post-treatment surveys were conducted in July of 1999. The 1,000 trees marked previously were surveyed for bear damage and received 2 additional orange dots of paint. We conducted the second post-treatment surveys in July 2000 and recorded new damage from the spring of 2000. Marked trees received 2 yellow dots of paint on opposite sides of the tree. We randomly replaced dead trees within each transect if the tree count was <1,000 trees/stand. After the bear damage surveys in July 2000, I randomly selected 2 treatment units in the Joyce area (J1 and J3) for discontinuation of the feeding program. The last surveys were completed in July 2002, and we recorded new bear damage from the spring of 2001 and 2002.

	Joyce		**1999 Pre**	**1999 Post**	**2000 Post**	**2001 Post**	**2002 Post**	Total
J1	Feed	Twin 2	390	1	5	Feeder	Feeder	6
	Control	Crescent Creek	375	21	22	removed	removed	43
J2	Feed	Bear Creek 2	498	5	2	8	12	27
	Control	PA-S 1000	527	37	33	33	24	127
J3	Feed	Bear Creek 1	249	1	55	Feeder	Feeder	56
	Control	Twin 1	151	29	21	removed	removed	50
J4	Feed	Majestic	84	3	2	2	2	9
	Control	East Twin River	151	24	33	15	26	98
Total	Feed		1221	10	64	10	14	98
	Control		1204	111	109	48	50	318

	Kalaloch		**1999 Pre**	**1999 Post**	**2000 Post**	**2001 Post**	**2002 Post**	Total
K1	Feed	Willoughby Ridge	154	2	2	0	1	5
	Control	Kalaloch 1	160	45	24	23	23	115
K2	Feed	Kalaloch 2	234	9	4	1	0	14
	Control	Clearwater 1100-1	265	3	15	0	0	18
K3	Feed	Clearwater 1020	189	13	2	3	2	20
	Control	Clearwater 1100-2	21	24	3	3	7	37
Total	Feed		577	24	8	4	3	39
	Control		446	72	42	26	30	170

Table 4.2 Black bear conifer damage data on 7 feeding and 7 control sites in Joyce and Kalaloch research areas.

4.3.3 Data analyses

I used a *t*-test to compare pretreatment counts of damaged trees on treatment and control sites. I used analysis of variance to evaluate changes in numbers of damaged trees between treatment and control sites and among years from spring 1999 to spring 2002. I analyzed 14 sites (7 pairs) during the first 2 years (n = 7 pairs) and 10 sites (n = 5 pairs) after the second year, since feeding stations were removed from 2 sites in summer of 2000.

4.4 Results

Pretreatment damage surveys showed means of 235.7 (range = 84–498) damaged trees per 1,000 trees sampled on treatment sites and 256.9 (range = 151–527) on control sites. I found no statistically significant difference between the number of damaged trees on treatment and control sites ($P = 0.60$).

The number of newly damaged trees was greater on control sites than on treatment sites in each year of my study (Table 1). Analysis of variance indicated no effect of year ($F3,1 = 1.17$, $P = 0.33$) on the number of trees damaged. During 1999–2002, bears damaged significantly more trees on control sites than on treatment sites ($F3,1 = 16.98$, $P < 0.001$).

Treatment was discontinued after 2 years in treatment sites J1 and J3. Bears damaged 6 trees during the first 2 post-treatment surveys on treatment site J1. After feeding stations were removed, bears damaged an additional 40 trees over the next 2 seasons, increasing damage by a factor of 7. Treatment site J3 was eliminated from the test because feeding stations on this unit were not maintained during 2000, and 55 trees were girdled on transect 4.

4.5 Discussion

After emerging from their winter dens, bears will eat the most palatable foods available first. If bears are given a choice between tree sapwood and ADCP pellets, bears seem to opt for the pellets to a substantial extent. If given a choice among sapwood, pellets, and berries, bears prefer berries. In July, bears quickly wean off the man-made feed.

The ADCP experience indicated that maintenance problems, empty feeding stations, or wet pellets are main reasons for failure of the black bear feeding program. In the J3 unit in Clallam County, 1 feeding station was accidentally not stocked for 1 week. As a result, we counted 55 girdled trees during the spring of 2000 along the transect where the feeding station was located, while the other 3 transects showed no damage. The ratio of damaged trees between treatment and control sites would have been higher without this avoidable mistake. Past feeding program failures also invariably occurred on sites with high bear densities (Ziegltrum 1994). Clallam County had historically high sport harvest success, which indicates high bear densities. Sport hunting was encouraged in areas with high bear population densities and where damage was unacceptable. Past experience has shown that population reduction, whether by sport hunters or through control programs, reduced bear damage. Therefore, lower bear densities likely equated to fewer damaged trees in general. Fewer or no bears needed to be removed from areas of vulnerable timber stands when damage was successfully reduced through the feeding program.

The K2 control unit near Kalaloch showed no bear damage in 2001 and 2002 but had normal activity and damage during the first 2 years. The Washington State Department of Fish and Wildlife and the land manager revealed that bears were killed around this research unit by sport hunters during the regular bear hunting season in 2000, which likely was responsible for the lack of damage.

Pretreatment surveys indicated the potentially high losses in timber production if no bear damage management practices are implemented. At least 25% of the pretreatment surveyed trees had suffered some damage inflicted by bears. This damage is compounded because these stands had already been thinned to pre-commercial stocking levels of about 1,000 stems/ha. Damage also usually occurs in pockets, often resulting in the complete loss of trees on several hectares in 1 area. Kimball et al. (1998*a*) suggested that openings allow sunlight to penetrate the canopy and shade-intolerant trees, such as Douglas-firs, respond with higher photosynthesis rates. The higher carbohydrate concentrations in the phloem probably increase the attractiveness of these trees to bears.

Survey results from the first year extrapolated to a 20-ha stand suggest that 769 of 20,000 trees (1,000 trees/ha) on untreated stands would suffer bear damage annually. These figures, applied across a 15-year vulnerable period, suggest anticipated damage to 11,535 trees. Damage estimates for the stands with feeding stations across the same 15-year period, using the same calculation, would be only 2,100 trees or approximately 10%.

Before feeding on pellets consistently, bears must learn that feeding stations do not present immediate danger from hunters. We often observed bears waiting at the previous year's feeding locations in early April, before feeding stations were installed. This suggests that longer-term feeding may reduce damage to a further extent over time as a function of learned behavior.

Nolte et al. (2001) indicated minimum competition among bears at feeding stations placed at the same site for several years. I speculate this lack of competition may occur because bears have learned that feeding stations provide an unlimited resource of food, unlike an animal carcass that provides only a short-term resource. If true, this response would require time for bears to learn, and competition for the pellets would be the greatest the first year that feeders are installed. If competition restricts bears' access to feeding stations, then excluded bears likely would peel trees in an attempt to meet their dietary demands.

4.6 Management implications

My study supports the anecdotal experience of Washington's foresters that the supplemental feeding program is a viable tool to alleviate bear damage to trees. Further, this study also indicates, as observed in the past, that removing feeding stations in established feeding areas may increase bears' tree-girdling behavior.

Future studies are needed to understand the economic efficacy side of the black bear supplemental feeding program. Our experience currently is based on 900 feeding stations maintained by the ADCP in western Washington in 2002. One feeding station costs $110. The price for pellets delivered to land managers last year was $495/ton. Little information is available on the total labor costs to maintain the feeding stations for 3 months, and I am currently investigating the costs and benefits associated with a supplemental feeding program.

4.7 Acknowledgments

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5 Cost-effectiveness of the black bear supplemental feeding program in western Washington

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Abstract

In 2004 I concluded that the black bear (*Ursus americanus*) supplemental feeding program was an effective, non-lethal damage control tool to protect conifers during the spring in western Washington, USA (Ziegltrum 2004). Consequently, I analyzed the costs of the supplemental feeding program, which is used for about 10 years from stand age 15 to 25 and the costs of accepting bear tree damage. One Douglas-fir (*Pseudotsuga menziesii*) stand with known yield data served as a model. I assumed 15, 25, and 35% tree damage by bears in this stand at age 15 and allowed the stand to grow to 35-, 40-, and 45-year rotations. I performed present value calculations (PV) for the costs of the feeding program to determine if it was the best expenditure for the Animal Damage Control Program (ADCP) in comparison. For the sensitivity analysis, I used 5, 6, and 7% interest rates. I found that the costs of feeding bears for 2.5 months annually were always lower than the costs of tree damage by bears. Therefore, I concluded that the supplemental feeding program was a cost-effective damage control tool.

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Key words: black bear damage, cost-effectiveness analysis, future value, non-lethal damage control, Pacific Northwest, present value, supplemental black bear feeding, *Ursus americanus,* Washington Forest Protection Association, Washington State.

5.1 Introduction

Efforts to manage wildlife damage are no longer resistant to the forces of supply and demand that drive the actions of private industry (Shwiff 2004). The spring black bear (*Ursus americanus*) supplemental feeding program in western Washington, USA, minimizes the bears' tree damage (Ziegltrum 2004) but is a cost factor. Douglas-fir (*Pseudotsuga menziesii*) stands are vulnerable to black bear bark girdling during the spring from age 15 to about 25, after pre-commercial thinning took place (Nolte et al. 1998). This damage is a significant economic problem, estimated in millions of dollars annually (Nolte and Dykzeul 2002). The Washington Forest Protection Association's (WFPA) Animal Damage Control Program (ADCP) developed the black bear supplemental feeding program in 1986 (Flowers 1986). It is a non-lethal damage control tool and is used in addition to lethal black bear damage control. The ADCP recognized in 1985 that providing wildlife with viable alternative foraging options can alleviate the extent of foraging pressure directed toward forest resources. The United States Department of Agriculture, Animal and Plant Health Inspection Service (USDA/APHIS) described the efficacy of the black bear supplemental feeding program as a non-lethal approach, which ‘‘overall reduces damage to Douglas-fir trees” (Nolte 2003). Partridge et al. 2001 describes the supplemental bear feeding program as ‘‘successful at reducing conifer damage during the early spring when other food resources are limited’’ (Partridge et al. 2001).

One black bear may peel 70 trees a day and can completely destroy a pre-commercially thinned young Douglas-fir plantation in 6 years (Ziegltrum 1994). In less damaged stands with partially debarked but surviving trees, the quality of the xylem of the most vigorous trees suffer because of decay from subsequent fungus and insect infestation (Kimball et al. 1998). Since nearly all tree damage occurs on the lower bole of trees (Nolte et al. 1998), the first 8 feet of the basal log may have no commercial value, especially in high-yield forests with short tree-stand rotations (Schmidt and Gourley 1992). Bear damage is not randomly distributed throughout a stand but is usually concentrated in a small area and, therefore, creates pockets (Schmidt and Gourley 1992). Average tree diameter of undamaged Douglas-fir trees at the edge of these pockets may even increase after bear damage occurred (Tables 1 and 2) because these trees have more sunlight available to photosynthesize, after dead trees lost their needles (Kimball et al. 1998). They also continue to be most vulnerable to the bears' bark peeling, since the total carbohydrate concentration in the phloem is greater in low-density stands than in mid- or high-density stands (Kimball 1997).

The ADCP uses feeding stations, at an annual cost of about $150,000 (U.S.) to protect about 400,000 ha of vulnerable timber stands during mid-April to the end of June (Adams 1992, Mitchell 2001). Feeding costs in 2004 were approximately $2.70/ ha for the industry in general. Individual costs ranged from $0.75–5.10/ha (Flowers 1988, K. Cross, Weyerhaeuser, Rainier, Wash., USA, personal communication).

My study examined only the costs of the black bear supplemental feeding program and the costs of bear tree-damage in western Washington. No national or international comparisons were made. Oregon and northern California feed bears but have no information on associated costs. Croatia used the ADCP pellets successfully around 1990 (D. Huber, University of Zagreb, Zagreb, Republic of Croatia, personal communication) and foresters of the town of Kiryu, Japan, received 1 ton of pellets annually over the last 3 years to protect trees from bears. International literature is mostly opposed to the supplemental feeding of wild animals to prevent damage. Schröder (1992) described initial experiences with the European brown bear (*Ursus arctos*) and observed damage to trees, sheep, beehives, buildings, and logging equipment in the Alps. Moog (2005) compared costs of animal damage management with the costs of accepting animal damage after 1 stand rotation in a private forest in Bavaria, Germany.

I researched the efficacy of the black bear supplemental feeding program from 1999–2002 and concluded that it was a viable damage control tool (Ziegltrum 2004). The cost-effectiveness of the feeding program was an important additional question for the forest products industry in western Washington. Therefore, I performed present value (PV) calculations to determine if this program offers the best expenditure for the ADCP's financial resources. The study helped foresters make the best investment decisions within their budget by showing under what conditions the supplemental feeding program was economically beneficial. My procedure also documented how the bear-feeding program could be analyzed under any number of assumptions and may serve as a guide for forest managers.

I hypothesized that providing black bears with the supplemental feeding program as an alternative food source during the vulnerable age period of a tree stand is economically beneficial to the forest products industry in western Washington.

5.2 Methods

5.2.1 Control stand

I chose 1 typical Douglas-fir stand in western Washington, established in 1963, for the case study. The stand was stocked with 790 Douglas-firs/ha, pre-commercially thinned and located in Cowlitz County, along the Cowlitz River, between longitude 122°75′00" and latitude 46°22°00". Site index was 125 (42 m height at age 50), and average rain fall was 0.25 m annually.

An actual stand table was developed from the Barnes Drive Relative Density Plots, which is still used at the Washington State Department of Natural Resources (DNR; Table 1). The plots were established in 1983 at stand age 20 (C. Chambers, DNR [retired], Olympia, Wash., USA, personal communication) and generated to ages 35, 40, and 45, which are typical harvest rotations for Douglas-fir on industrial forest lands in these areas. I used the DNR Intensive Management Program Simulator (DNRIMPS) for the stand volume calculations, which were updated to better reflect different levels of bear damage (Chambers 2004).

Control stand 0% damage			
Rotation age	35	40	45
Board feet/ha	72,381	95,544	106,637
Trees/ha	753	741	729
Diameter at breast height (m)	0.31	0.32	0.33
Stumpage dollar value/ha	30,959	40,587	46,105

Table 5.1. Douglas-fir control stand characteristics in Cowlitz County, Wash., USA, with 0% bear damage and no supplemental feed applied. Volume loss of 10% is assumed at 3 rotation ages because of malformed trees, weather related damages, logging losses or holes in the stand.

5.2.2 Damage definition

Pretreatment damage surveys during the efficacy study in 1999 showed means of 235.7 (range 84–498) damaged trees per 1,000 trees sampled on treatment sites and 256.9 (range 151–527) on control sites, with no significant statistical difference (P = 0.60) between them (Ziegltrum 2004).

Damage in this cost-effectiveness analysis was defined as the percentage of trees hit by bears at age 15. Surveys showed about 30% of the damaged trees in a stand to be 100% girdled; these died within the following year, providing no revenue (Schmidt and Gourley 1992; Ziegltrum 1994; 1996, Miller et al. 2005). Based on 790 trees/ha and 15% damage with 30% mortality, 119 trees would suffer some form of bear damage. Of these 119 trees, 38 would be 100% girdled and die the following year. At the 25% damage level, 198 trees/ha would be hit by bears, and 59 would die. Assuming 35% tree damage, 277 trees/ha would be damaged, and 83 of them would die within 1 year. About 10% of all damaged trees would be debarked by 76–99% and would have additional mortality of 5% from windbreak, fungus, and insect infestation at harvest age (Schmidt and Gourley 1992, Ziegltrum 1994). The surviving trees would provide revenue but the basal logs would be lost. About 60% of the damaged trees would have bark loss between 1–75% (Schmidt and Gourley 1992) but would survive and the top and middle logs would provide revenue.

With these assumptions, I modeled tree loss for minimum tree damage of 15%, average tree damage of 25%, and maximum tree damage of 35% (Table 2). For the PV calculations, I used a sensitivity analysis with 5, 6, and 7% interest rates, since these rates are common for the forest products industry in Washington.

The control stand was reduced from the gross volume by 10% to reflect the actual timber volume at harvest because of malformed trees, weather-related damages, logging losses, and holes in the stand. I also used 10% of loss for the bear-damaged trees in the upper logs for the same reasons.

15% damage			
Rotation age	35	40	45
Board feet/ha	62,763	83,923	94,060
Trees/ha	709	697	684
Diameter at breast height (m)	0.31	0.33	0.34
Stumpage dollar value/ha	26,787	36,163	40,335
25% damage			
Rotation age	35	40	45
Board feet/ha	55,237	72,959	88,090
Trees/ha	682	667	657
Diameter at breast height (m)	0.32	0.33	0.34
Stumpage dollar value/ha	23,475	31,371	37,719
35% damage			
Rotation age	35	40	45
Board feet/ha	50,398	67,881	85,751
Trees/ha	652	640	627
Diameter at breast height (m)	0.32	0.34	0.35
Stumpage dollar value/ha	21,380	29,008	36,828

Table 5.2 Douglas-fir stand characteristics in Cowlitz County, Wash., USA, with assumed bear-damage levels of 15, 25, and 35% at rotation ages of 35, 40, and 45 years.

5.2.3 Value calculations

Approximately 70% of the tree's height is merchantable. Usually, 3 logs can be cut. The top log represents about 9% of value and the middle log 28% of the value. Most valuable is the basal log with about 63% (Mosman 2004). The stumpage calculation was based on the simulated stand table from DNRIMPS. I projected the stand tables with a modified version of a standard DNR logscale tree-volume tariff computer program to fit the bear-damage losses better and to generate the trees diameter at breast height (DBH) class/ha (Table 2; Chambers et al. 1976). Each tree by DBH class was cut into 9.7-m logs (32 feet). The board foot volume of each log was assigned based on the inside bark diameter (DIB), according to the yield table. The logs were sorted in 3 DIB classes: logs $\leq$0.18 m, logs >0.18–0.41 m, and logs >0.41 m.

I assigned the log value based on the average log values for western Washington in December 2004. Once all DBH classes were completed, I calculated total log price. Logs for chip and saw wood $\leq$0.18 m have a value of $487/thousands of board-feet per acre (MBDFT), saw logs >0.18 m – 0.41 m have a value of $630/ MBDFT, and saw logs >0.41 m are valued with $580/MBDFT. I then calculated the stumpage/ha by subtracting the logging costs of $150/MBDFT.

5.2.4 Future value (FV) supplemental feeding costs

Within a vulnerable stand at age 15, PV costs of the feeding program are $2.70/ha annually. These costs need to be paid for 10 years to stand age 25, when bear damage ceases. At the end of this period, these feeding costs are prolonged to the end of the stand rotation. I performed PV calculations for 35-, 40-, and 45-year stand rotations, $FV = PV \times (1 + i)^n$,where i = interest rate and n = compounded years. Assuming a maximum interest rate of 7% and a maximum stand rotation of 45 years (n = 30), the FV cost for the black bear supplemental feeding program is $21/ha.

**Fig. 5.1: Bear at supplemental feeding station.
Photo: Courtesy of Green Crow Timber Company**

5.3 Results

The black bear supplemental feeding program was economically beneficial under all damage, interest rate, and rotation age scenarios. Compared with the control stand, the discounted value of the stand at age 15 (Table 3) without the feeding program was reduced by 13% at a stand rotation of 35 years and bear damage of 15%, independent of the real interest rate of 5, 6, or 7%. At rotation age 40, this stand lost 11% of its value, and at rotation age 45 it lost 13%. More significant was the loss of value at a 25% damage level. At rotation age 35, the stand lost 24% of its value at the assumed interest rates. At rotation age 40, it lost 23%, and at age 45, it lost 18% of its value. The difference in value was most significant at a damage level of 35%. At rotation age 35, the stand lost 31% of value, 29% of value at age 40, and 20% of its value at age 45, assuming interest rates of 5, 6, and 7%.

	Real interest %	Rotation age 35	Rotation age 40	Rotation age 45
0% damage	5	11,668	11,985	10,668
	6	9,653	9,458	8,028
	7	8,000	7,440	6,057
15% damage	5	10,095 (13%)	10,678 (11%)	9,332 (13%)
	6	8,354 (13%)	8,425 (11%)	7,022 (13%)
	7	6,924 (13%)	6,664 (11%)	5,298 (13%)
25% damage	5	8,848 (24%)	9,265 (23%)	8,729 (18%)
	6	7,319 (24%)	7,309 (23%)	6,546 (18%)
	7	6,066 (24%)	5,780 (23%)	4,955 (18%)
35% damage	5	8,057 (31%)	8,566 (29%)	8,522 (20%)
	6	6,667 (31%)	6,758 (29%)	6,410 (20%)
	7	5,525 (31%)	5,345 (29%)	4,839 (20%)

Table 5.3 The western Washington black bear supplemental feeding program (1992–2002) was economically beneficial under all damage, interest rate, and rotation age scenarios. The future stumpage value is discounted back to the year 15, when damage occurred. The cost of $2.70 (U.S.)/ha for the feeding program is included in the control stand values. The percentage difference is the amount of discounted income a stand lost at age 15 because the black bear supplemental feeding program was not implemented.

5.4 Discussion

There could be endless examples with regard to stand quality, bear damage severity, with many assumptions of income loss through other animals, interest rate at harvest age, stand rotation, stocking, yield, and weather damage. My model was based on 1 typical Douglas-fir stand in the Pacific Northwest and showed that the supplemental feeding program was cost-effective under a wide spectrum of scenarios. I chose a site index of 125 for the case study because bear damage usually is low on poor growing sites, since the concentration of carbohydrates in the phloem provides no incentives for bears to peel such a tree (Kimball et al. 1998).

Currently, there is only the supplemental feeding program and lethal removal of bears with the assistance of hound hunters and the Aldridge foot snare available in western Washington to control black bear damage. In comparison, foresters in Oregon concentrate their damage control efforts with the Aldridge food snares and are willing to spend $65/ha to protect their timber resources (K. Cross, Weyerhaeuser, Rainier, Wash., USA, personal communication). The USDA investigates the use of contraceptives for bears, fencing of vulnerable tree stands, quartz sand to discourage bears from peeling trees, and multiple tree age–classes within a stand. None of these alternatives promise any practical and cost-effective solution for the near future for the forest products industry.

Wildlife does not have a clearly defined market value since it is not determined by supply and demand (Shwiff 2004). However, there are many different ways to develop a range of values for wild animals, based on license fee costs, illegal take penalties, or the amount of revenues garnered by hunting animals (Loomis and Walsh 1997). It is becoming more important for private forest managers to recognize the value of a bear, which is not killed to protect timber resources by using a non-lethal approach, since this bear is then available for hunters in Washington who are an important economic consideration.

The black bear supplemental feeding program was frequently introduced to the public in Washington over the last 15 years in newspaper articles, on radio, and on television news. The public feedback on non-lethal damage control tools was always positive. Working relationships with animal rights groups improved greatly during this time. The forest products industry in Washington recognized the benefits of using the black bear supplemental feeding program in 2 ways. In addition to saving timber resources and increasing revenue, it proved to positively influence public opinion about private forest management.

5.5 Management implications

I found that the black bear supplemental feeding program is a cost-effective, non-lethal black bear damage control tool to protect conifers during the spring in western Washington. The costs of this program over 10 years were always lower than the costs of accepting bear damage over the same time period. Landowner investments are expected to pay off at stand harvest age, which typically is between 35 and 45 years in this region. Thirty-two ADCP members represent 1.3 million ha of forests in western Washington of which 400,000 ha are vulnerable to black bear girdling. Over the last 7 years, the forest products industry used about 450,000 metric tons of pellets annually in 900 bear-feeding stations (Ziegltrum 2003).

Since 1996 the ADCP has reached a threshold with about 450,000 metric pounds of pellets annually. The total amount of pellet use will not appreciably change over the next 20 years since the vulnerable timber base will not change (Adams 1992). The supplemental feeding program may, therefore, continue to be used in the future, unless more effective tools are found.

5.6 Acknowledgments

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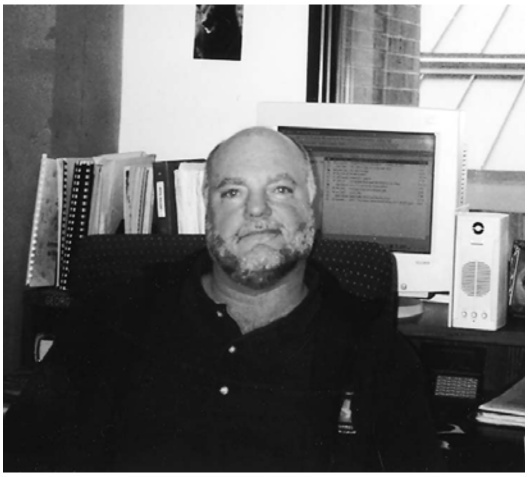

Fig 5.2: ***Georg J. Ziegltrum*** was born in Munich, Germany. He studied optometry in Bavaria and worked in this profession for 6 years. In 1980 Georg developed an interest for forest and wildlife management and begun the study of forest and wildlife ecology at the Georg–August University in Goettingen, Germany, where he received an M.S. In 1988 Georg moved with his American wife to Washington where he worked as a cook and guide for a hunting outfitter and later as a lifeguard at the Chelan City Park during the summer. In February of 1989, Georg accepted a position with the Washington Forest Protection Association (WFPA) as Animal Damage Control Program supervisor. In 1991 he worked temporarily with the Washington State Department of Fish and Wildlife as area biologist in Aberdeen but was offered a full-time position with WFPA as staff biologist the same year. Over the last 10 years, Georg concentrated his work on black bears and studied in cooperation with the United Stated Department of Agriculture, Animal and Plant Health Inspection Service many aspects of damage management. Georg has well-established research connections to Germany, Austria, and Croatia. His current responsibilities for WFPA include animal damage control management and associated research, publications, public relations, policy work with legislators and the Washington State Fish and Wildlife Commission. In addition, Georg coordinates the Washington Tree Farm Program for WFPA.

6 Impacts of the black bear supplemental feeding program on the ecology in western Washington

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6.1 Origins of the bear-feeding program

6.1.1 Problem of tree girdling

Black bears (*Ursus americanus*) are opportunistic omnivores (Simpson 1945) that feed on grasses, grub, insects, and berries, and scavenge from animal carcasses. During the spring, they girdle trees to feed on the newly forming phloem (Poelker and Hartwell 1973, Noble and Meslow 1998, Partridge et al. 2001). Extensive black bear damage to conifers coincided with the beginning of intensive forest management on industrial and smaller private lands in western Washington during the early 1940s. High-yield tree plantations (i.e., tree farms) required protection to reduce tree girdling by black bears. Bear damage occurrence and frequency was recorded on Douglas fir (*Pseudotsuga menziesii*) (Fig. 6.1.), western hemlock (*Tsuga heterophylla*), and western red cedar (*Thuja plicata*) during the mid-1950s after bear damage had spread across most of the Pacific Northwest (Lauckhart 1955).

Damage from bears girdling within a stand of trees can be extensive; a single foraging bear may peel bark from as many as 70 trees per day (Schmidt and Gourley 1992). Tree damage can be detrimental to the health of timber stands, reducing their economic value by millions of dollars annually in Washington (Nolte and Dykzeul 2002). Trees completely girdled during the spring appear red as their vigor declines and their needles become discolored. Partially girdled trees are physiologically stressed, and their needles will appear light green to yellow (Ziegltrum 1994). Dead trees appear gray because they have lost most of their needles. Because of this, areas containing bear-damaged trees can be mapped from the air and are later verified by ground truthing. Ground surveys usually detect 3 to 4 times more damaged trees than are originally detected from the air. Bears leave stripped bark on the ground around the base of the tree, and vertical tooth and claw marks are generally visible on the bole. Mountain beavers (*Aplodontia rufa)* and porcupines (*Erethizon dorsatum)* may also girdle the bole near the ground of similar-age trees, though damage inflicted by these species is easily distinguishable from bear damage (Nolte and Otto 1995).

Fig. 6.1: Typical black bear damage on 20 year old Douglas fir during spring in western Washington. Drawing: Modified by Ziegltrum.

Complete girdling is lethal to trees, while partial girdling provides avenues for subsequent insect and disease infestation (Kanaskie et al. 1990). The severity of timber loss is compounded because bears select the most vigorous trees within the most productive stands, usually where stand improvements, such as thinning and fertilization, have been implemented (Mason and Adams 1989, Nelson 1989, Kanaskie et al. 1990, Schmidt and Gourley 1992, Kimball et al. 1998). Preference of bears for a particular tree or tree species may change with the phenological stage of the tree (Nolte et al. 1998). For example, hemlocks are generally damaged earlier in the spring than are Douglas firs because of an earlier bud burst. Damage declines during late June as berries and other alternative foods become more readily available (Ziegltrum and Nolte 1995).

6.1.2 Beginning of supplemental bear feeding

The Washington Forest Protection Association (WFPA), un umbrella organization of the forest products industry in Washington State, confronted tree-girdling by bears in 1959, and the Animal Damage Control Service (ADCS) was organized in 1960 (Ziegltrum 1998). The ADCS executed basic field work such as damage surveys, hunting with hounds and snaring but had no research responsibility. This cooperative program between the Washington State Department of Natural Resources (DNR) and private forest land managers was intended to minimize black bear damage by depressing bear populations in areas of heavy tree damage. The damage control program was initially tolerated by the public, but in the early 1980s increased awareness resulted in greater criticism of killing bears for the benefit of growing trees (Flowers 1986). Consequently, the WFPA proposed the black bear supplemental feeding program during the spring as a non-lethal bear damage control strategy. R. H. Flowers of the WFPA started producing feed pellets in his own mill in Aberdeen, Washington. The challenge was to find a pelletized food that was more palatable to bears than sapwood but less palatable than berries. The original pellet was composed of a mixture of meat meal, bone meal, molasses (39%), and a mash of ground sugar beet pulp, cane sugar, salt, magnesium sulfate, anis feed aroma, and swine vitamin minerals (61%). The mixture was then tested for 3 months on 2 captive bears in Olympia, Washington. It was later field tested at a 40-ha unit near Kalaloch, Washington (Flowers 1986).

The ADCS was renamed Animal Damage Control Program (ADCP) since the responsibilities of the program supervisor now included the coordination of research among the stake holders in addition to the field work. The ADCP planned to feed free-ranging bears for only 2–3 months during the spring, before wild berries became ripe. In early July, bears needed to wean off the pellets naturally. Initial feeding results during 1985 were impressive because bear damage was reduced and ceased altogether in some stands. Tests continued for 2 more years with similar results.

Spring supplemental black bear feeding as a damage control tool on large areas of industrial forest lands began in western Washington in 1990. At the time, the Washington State Department of Fish and Wildlife (WDFW) estimated the black bear population in Washington to be 25,000–50,000 animals (Tirhi 1996), and it was obvious that supplemental feeding needed to be concentrated at timber stands with severe damage or it would become too expensive and unmanageable. The Weyerhaeuser Snoqualmie Tree Farm in western Washington used the black bear supplemental feeding program in an 18-year-old, pre-commercially thinned Douglas fir stand with a 2-year history of black bear damage during the same year. Five feeding stations were installed from April 20 to June 30 and stocked with 5,000 pounds of pellets. Beaver carcasses were hung from nearby trees initially to attract the bears to the feeding sites. Surveys in August 1988 showed no additional trees damaged during the spring throughout the unit (Flowers 1988).

Over the next 7 years, the ADCP expanded its bear feeding operations in western Washington to most bear-damage sites and each year doubled the total amount of feed distributed to bears. In 1995, the ADCP was feeding about 3,000 black bears. This estimate was based on bear tracks in front of feeding stations, the amount of pellets eaten per week, the total amount of pellets consumed during the spring, and a feeding period of 70 days. A feeding station held 125 kg of pellets and was stocked weekly (Fig. 6.2.). We determined the amount of pellets bears ate each week by weighing the pellets which we added to fill the feeding stations. We concluded that 1 bear ate 0.5 - 1.5 kg of pellets daily. In 1996 a threshold was reached with 850 to 900 feeding stations and approximately 225,000 kg of pellets distributed annually. The feeding program was protecting about 400,000 ha of pre-commercially thinned 15–25-year-old Douglas fir stands (Adams 1992, Mitchell 2001, Ziegltrum 2004).

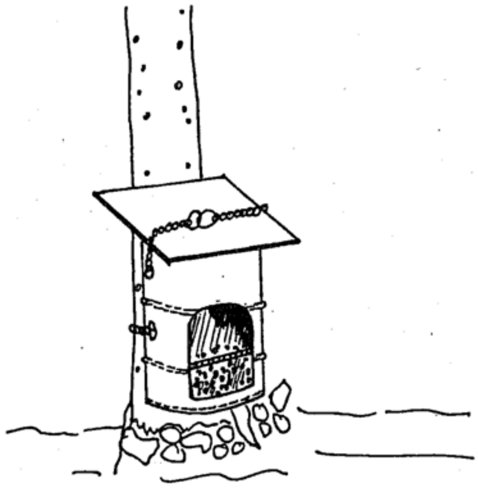

Fig. 6.2: Black bear spring feeding station as used in western Washington. Each station holds up to 125 kg of pellets. Drawing: Ziegltrum.

6.2 Concern about the bear-feeding program success

The population density of bears at newly-established feeding stations increased each year and foresters started to fear a potential loss of the efficacy of the feeding program in 1994 (Ziegltrum 1994). Land managers asked if intensive use of the supplemental feeding program could create more bears with higher reproductive success, particularly in areas where low bear densities were desired. The ADCP received permission from the WFPA's executive committee and the WDFW to investigate this concern in 1997 and field work began in March 1998. The ADCP trapped and radio-collared 17 bears in feeding areas between Rochester and Oakville and 8 bears in non-feed areas in the Capitol Forest. The bears were immobilized with Telazol (5.0–7.0 ml/kg) using Palmer Cap-Chur dart guns (Fort Dodge Laboratories, Fort Dodge, Ia.). The reproductive success of bears that used feeding stations was monitored and compared with the reproductive success of bears without access to feeding stations. The telemetry data, supported by the video monitoring of marked bears, showed a higher concentration of bears around areas with feeding stations only during the spring. The bear concentration increased annually because sows brought their cubs to the feeding stations and not because bears were drawn in from non-feed areas. We observed that after 2-year-old bears were weaned off their mothers, they continued visiting feeding stations. One yearling male visited a feeding station with its mother in early spring and came alone in June, having remembered locations of feeding stations within its range. In June, its mother visited multiple feeding stations with different males accompanying her. She brought her new cubs to the feeding stations 1 year later. During the spring of 1999, we found no difference in cub production after bears emerged from their winter dens in March of the next year.

Foresters also were concerned about the safety of their feeding personnel, because 90% of injuries by bears to people were inflicted by bears that were conditioned to associate humans with food (Herrero et al. 1998). Hence personnel were encouraged to carry firearms for personal protection.

In interviews I conducted, ADCP feeding personnel repeatedly reported sightings of bears at established feeding locations. Black bears often waited around empty feeding stations for feeding personnel but stayed out of sight. Typical bear behavior in western Washington was to avoid contacts with humans despite the connection they obviously made between feeding personnel and food in feeding stations. Bears typically walked away from feeding stations when feeding personnel approached, but they waited close by. When feeding personnel left the feeding stations, bears walked back to the feeders within minutes and continued to feed on the pellets. The ADCP has no reports of any bear–human conflicts, human injuries, or any incidents during 20 years of stocking black bear feeding stations.

6.3 Impact of the feeding program on bears

6.3.1 Impact on bear behavior

Land managers raised concerns about undesired impacts of extended supplemental feeding of black bears. In 1996, foresters became concerned that dominant male bears prevented other bears from accessing the feeding stations. In the spring of 1998 and 1999, Nolte et al. (2000) tested this hypothesis and captured 17 bears, using Aldridge foot snares. The ADCP team earmarked or radio-collared the bears for later identification. In April 1999, 4 areas with established feeding stations about 5 km apart from each other were selected. Four platforms were built around a tree in each area about 4 m above the ground. The platforms were about 10 m away from the feeding stations and mounted with 1 Panasonic video camera, a Pelco motion detector, and a Panasonic time-lapse recorder and television system. Marine batteries powered the equipment. Bear behavior and interactions around feeding stations were videotaped from May 1 to July 10, 1999. Bears approaching the feeding stations triggered the motion sensor mechanism, and the cameras videotaped the bears' activities.

Twenty bears, including the 17 earmarked animals, visited the videotaped feeding stations. Female bears with and without cubs or yearlings, males of all age classes, came to the feeders but fed at different times. Only one sow was accompanied by an adult male during mating season in June and shared the feeding station. Most bears visited at least 2 feeding stations, and several were videotaped at all 4 feeding stations. Bears showed up at feeders every 2–3 days and stayed for 15 minutes or less. Mean feeding time (i.e., amount of time bears had their heads in the feeding stations) was only 1.5 minutes. Bears fed at feeding stations throughout the day but preferred the early morning, late afternoon, and the evening hours. Lactating females were very alert around feeding stations and kept the cubs close. Adult male bears showed little concerns while feeding on pellets. All bears had equal access to the feeding stations throughout the 2.5 months of observations. They seemed to have learned that feeding stations provided an unlimited source of food and therefore showed very little antagonistic behavior. The study concluded that adult male bears did not dominate feeding stations. Black bears did not become dependant on the supplemental feeding program throughout the year.

Fersterer et al. (2001) investigated impacts of supplemental bear feeding on bears' movement patterns, documenting home range sizes for male and female bears. In 1999, 25 bears, of which seventeen fed regularly at the feeding stations around Oakville and Rochester, and eight with no access to feeding stations in the Capitol Forest were radio-collared. Movements were monitored from May 1 to June 30, when bears used the supplemental feeding stations, and later, between the end of July and beginning of October, before winter denning. The well-designed road system enhanced the efforts to locate bears from a car by telemetry triangulation. Bear locations were repeatedly identified by triangulating telemetry points until the error ellipse of all points was smaller than an area 35 m^2. A 3-factor analysis of variance was used to compare home range size differences among: (1) bears with and without access to feeding stations, (2) males or females, and (3) periods of telemetry triangulation (during feeding on feeding stations or after bears weaned off the feeding stations). The home range and size were then established using the minimum polygon method with a 5% reduction of the area (Kenward 1987).

The study concluded that male bears generally had larger home range sizes than females, but this difference was consistent across feeding and non-feeding areas. The home range size among bears in feeding areas did not differ ($P > 0.35$). Bear densities around feeding stations increased only during the spring feeding period and home ranges were therefore temporarily smaller in comparison to those bears without access to pellets.

6.3.2 Impact on bear nutrition

Robbins et al. (2004) studied the nutritional ecology of bears and summarized the supplemental black bear-feeding program as a tool that successfully reduced conifer damage in the Pacific Northwest. Foresters in western Washington came to the same conclusion based on field observations and wanted to know how the bear feeding program influenced the bears' nutrition. They argued that well fed bears may reproduce more successfully than non-fed bears. To determine this, Partridge et al. (2001) researched dietary needs and weight gain of bears which frequented feeding stations. Partridge used Aldrich foot snares to trap 22 female and 31 male bears 68 times during April and May 1998–2000 before bears started accessing the feeding stations. In non-feeding areas, 11 female and 12 male bears were snared in 28 captures during the same time period. Partridge immobilized, ear-tagged, and injected the bears subcutaneously above the neck with a passive integrated transporter (PIT tag; Avid Power Tracker II Multi Mode Reader, Norco, Calif.). Partridge radio-collared the bears with standard VHF equipment (Advanced Telemetry Systems, Isanti, Minn.), weighed them, and extracted 1 molar to age the animals. Bears recognized foot snares quickly after being trapped once and were therefore recaptures with culvert traps and hounds at 4-week intervals. Blood samples were taken to analyze the diet of the bears through isotopic analysis in the laboratory (Hildebrand et al. 1996). Scat analysis verified the species of plant material ingested by bears (Partridge et al. 2001). All bears recaptured in areas with feeding stations consumed food pellets but also fed on grasses, forbs, and invertebrates. Partridge estimated that sapwood comprised 3% of their diet. Pellet fed bears gained more body mass during the supplemental feeding period than did the bears without access to the pellets. However, non-fed bears compensated for short-term weight differences in spring by increased berry foraging during summer and fall of the same year. Bears in the non-feed areas gained weight 3–4 times faster during the rest of the year than bears feeding on pellets in spring (Welch et al. 1997, Partridge et al. 2001). Body compositions of bears in both feeding and non-feeding areas (28% fat and 72% lean body mass) were similar and were characteristic of bears in other areas. Thus body composition was not influenced by pellet consumption (Hildebrand et al. 1999, Partridge et al 2001). Bears with access to pellets had roughly the same body weight when entering their winter dens in late November as bears without access to pellets. Winter survival was not different among fed and non-fed bears.

6.4 Conclusion

The black bear supplemental feeding program successfully deterred bears from damaging trees. In addition to the US States Washington and Oregon, ADCP pellets are used since 2003 in Asia, Prefecture of Gunma, Japan to protect Japanese Cedar (*Cryptomeria japonica)* stands within 150 km SE of Tokyo (B. Kamiyama, Kiryu, personal communication). Forest managers in Croatia, Europe, produced their own pellets since 2002, using the ADCP formula (D. Huber, University of Zagreb, Croatia, personal communication). It also stimulated an international discussion about the pros and cons of a supplemental feeding program and the implications for forest management.

All age classes and gender of bears fed on the pellets, including female bears with cubs. Although large bears did not dominate feeding stations, they did mark and destroy some trees to attract females during the mating season in early summer. This behavior was not an economic problem and did not trigger control action. The supplemental feeding program had no influence on the home ranges of bears throughout the year with the exception of the 2.5-month period in the spring when supplemental food was provided. The ADCP had no reports of conflicts between bears and feeding personnel. The reproductive success among fed and not fed bears was similar.

6.5 Acknowledgments

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7 Epilogue

The first settlers of the Pacific Northwest saw unlimited virgin forests. Efforts to exploit the forests of Washington from 1850 over the next 80 years, did not allow much space for any other resource considerations but wood. With rapidly expanding human populations and their demands for space and resources came also better and more effective timber harvest technologies to further civilization in the west. Only a few men critiqued the practice of logging these original forests so quickly. Samuel Bowles, editor for the "Republican" in Springfield, Massachusetts wrote in 1865 after he traveled across Washington and Oregon: "The business is but in its infancy; it will grow with the growth of the whole Pacific Coast, …. for it is impossible to calculate the time when, cut and saw as we may, all these forests shall be used up, and the supply become exhausted" (Hurd and Houghton 1865). Today, the forests of Washington and Oregon are managed on a sustained yield basis and the timber supply is certainly not exhausted. However, we have reached the end of virgin timber stands as predicted by Bowles. Only some small units of old growth stands on federal lands are still untouched.

Timber harvest techniques were limited to clearcuts. Whole drainages were logged right down to creeks. After the timber harvest, one hoped for natural regeneration to establish new forests. The public referred to this practice jokingly and disrespectfully as "cut and run strategy" but continued to support logging practices. Most communities in Washington were much dependent on the forest products industry to make a living. Management changes came in 1941with the first reforestation efforts taking place on the Weyerhaeuser "Clements Tree Farm", near Cle Elum

(Simpson 2000). Foresters did not yet take responsibility for other resources connected to forests and continued to concentrate on the harvest and regeneration of merchantable timber. Wildlife, for example, was plentiful and of little concern. The negative impacts of large scale timber harvest on many other resources were clearly rejected. Neither foresters nor biologists looked at the ecosystem but devoted their time to their individual knowledge and talents. Forests and wildlife were managed separately and not as a whole (Thomas 1985). This separation is still visible today as the two independent Washington State regulatory agencies, the Washington State Department of Fish and Wildlife (WDFW) and the Washington State Department of Natural Resources (DNR) prove.

Large clear cuts and their visual impacts changed the public's attitude towards forest management techniques around 1970 (Brown 1985). People and politicians expected resource management plans which included all resources while political pressure for general environmental protection rose. A new national era for forest land managers began, characterized by new, federal laws and requirements to deal with a more comprehensive and multiple-use based management. The National Environmental Policy Act of 1969, the Forest and Rangelands Renewable Resource Planning Act of 1974, the National Forest Management Act of 1976, and the Federal Land Policy and Management Act of 1976 forced federal forest managers to change resource management strategies. These United States Federal laws are the primary statues governing the administration of national forests. Legislation in 1976 reorganized existing laws and required the secretary of agriculture to assess forest land, and develop and implement a resource management plan for each unit of the National Forest system. Private forest managers saw the writing on the wall as rules and regulations to practice forestry changed for them as well. Finally, private forest land owners evolved from a harvest oriented industry to a resource oriented industry, taking responsibility for all impacted resources.

Naturally, the emphasis for the forest products industry continues to be wood. High yield forest management continues to optimize wood production by prescribing periodic silvicultural treatment, such as pre-commercial thinning and fertilization, to maximize economic value in the shortest possible time. But timber harvest on private lands was now reviewed by the DNR to insure no negative impacts on public resources. Wildlife threatened and endangered animal and plant species, clean water, clean air and cultural resources were now part of the evaluation process for timber harvest permits. Cooperative working relationships with the regulatory agencies were established to discuss forestry, wildlife and wildlife habitat requirements on private lands (Gutzwiler, personal communication 2005). Wildlife damage management strategies were among the issues of early discussions. Hunters as well as animal rights advocates supported the investigation of alternative, non-lethal damage management tools. In cooperation with the United States Department of Agriculture, Animal and Plant Health Inspection Service (USDA/APHIS) many additional strategies were researched to minimize animal damage in general. Most strategies to minimize bear damage such as frightening devices, fences, contraceptives and repellents were rejected. They were too expensive and impractical for large industrial forest land owners.

7.1 Forest/wildlife challenges

Black bear damage management is currently a silvicultural, political and public relation challenge for foresters in Washington State. Expanding brown bear populations in Europe are creating similar challenges for forest managers in Austria, Croatia and Slovenia (Huber, personal communication 2005). Fritz Nüsslein recognized the challenge of forest/wildlife ecology early on and summarized the responsibilities of today's forest/wildlife resource managers when he wrote in an essay: "It does not take great skills to practice forest management and science if one could eliminate the factor wildlife and it also is not difficult to practice wildlife management if one could ignore the forest. It is skilful however to practice both in a way that gives justice to forest and wildlife equally. Practicing this art is supported by the legislation and, in addition, fascinating" (Schröder, personal communication 2004). The originator of a similar statement, frequently used in Washington State, is long forgotten but the message is similar: "As the vegetation is, so the animals are". This is a highly simplistic statement regarding the distribution of wildlife and its habitat use. Nevertheless, it explains the importance and complexity of understanding the succession patterns of forest vegetation and its influence on the distribution and abundance of many species of wild animals.

Whether people decide to manage forests to reach a certain objective such as economic value, wildlife habitat, recreation, or leave forest succession up to nature, the consequences for wildlife are the same. There is no forest stand condition which serves all wildlife species at the same time equally well. Wild animals are adapted to different kinds of stand conditions, from clear-cut openings to old growth.

Silvicultural treatments of stands affect wildlife habitats in many ways. All stand conditions are therefore equally important and need to be provided throughout a landscape mosaic. Elk, for example, is best suited for the open grass lands. It thrives in open areas because early succession produces forage. The eruption of Mount St. Helens in 1980 produced perfect habitat for ungulates since the forests died off in large areas, sunlight reached the forest floor which encouraged the growth of shrubs and herbs. As a result, the local elk (and deer) herd increased significantly. Thermal cover is not necessary for elk surviving in western Washington because of the mild climate throughout the year. Forests and forest edges are still important for hiding cover, particularly during the hunting season. Elk travel corridors between large areas need to be provided by foresters to discourage genetic isolations. Nearly the opposite habitat requirements are true for the northern spotted owl. Optimum habitat for the owl is defined as multi- storied, uneven-aged, old-growth forest of 80 to 100 years of age. Nesting opportunity and hunting for rodents such as the flying squirrel are best in natural, old stands with structural damage and decay. Western Washington and Oregon are winter range for the bald eagle which is frequently seen nesting, perching and roosting around the large water bodies of the Puget Sound. In general, the eagle prefers any forest stand with a few very tall trees for perching. These tall trees are usually within 100 meters of the water shore line and are the eagle's base for hunting fish and small mammals. The wildlife symbol of the Pacific Northwest is doubtlessly the salmon. This species requires cool, fresh and clean water for spawning and rearing. Shade along creeks is therefore maintained by leaving large trees along riparian areas. Forest management can severely impact fish habitat through sedimentation from logging or road construction and great care to avoid these problems need to be taken. One of the most adaptable wild animals in Washington is the black bear. It can survive in many different forest stand condition. Abundance of food, particularly wild berries from the end of June to November as found in all elevations throughout forested regions of Washington, is essential. Washington's forest management creates large openings which produce berries and other forage for bears. The carrying capacity of the land for bears is not reached since there are no signs of an intra-specific stress situation. Wildlife managers estimate a black bear population increase of 3% annually (Tirhi 1996).

7.2 Options to avoid black bear damage

Today, three options are available to reduce black bear damage on private lands.

1) Bear population control during the regular black bear sport hunting season and bait hunting, hound hunting and trapping with the Aldridge foot snare during the spring damage control season (Fig. 3.2.2, 3.2.3); 2) The supplemental feeding program (Fig. 3.2.4, 7.3); and 3) Silvicultural stand manipulations to minimize the attractiveness and vulnerability of tree stands to bears.

7.2.1 Black bear population control

Damage control measures through population control during the spring and the feeding program are administered by the Animal Damage Control Program (ADCP) in cooperation with the WDFW. Since the successful passage of Initiative 655 in 1996, sport hunters are not permitted to hunt bears with hounds during the regular bear hunting season from August 1 to November 15. Hound hunting is permitted by law only to protect public health and safety as well as to protect private property. Sport harvest success of bears without hounds dropped by half during the first two years after initiation of the new law. Over the last five years boot hunters learned to call bears in and the sport harvest is again rather successful, averaging 1,500 bears in Washington annually. Sport harvest however is a random harvest while the damage control harvest needs to target specific areas – areas with high black bear damage (Fig. 7.1). The law still allows the use of hounds during the spring damage control hunts. Since 1996 these spring bear control hunts increased from a few bears to an average of 150 bears over the last 10 years annually (Ziegltrum 2003).

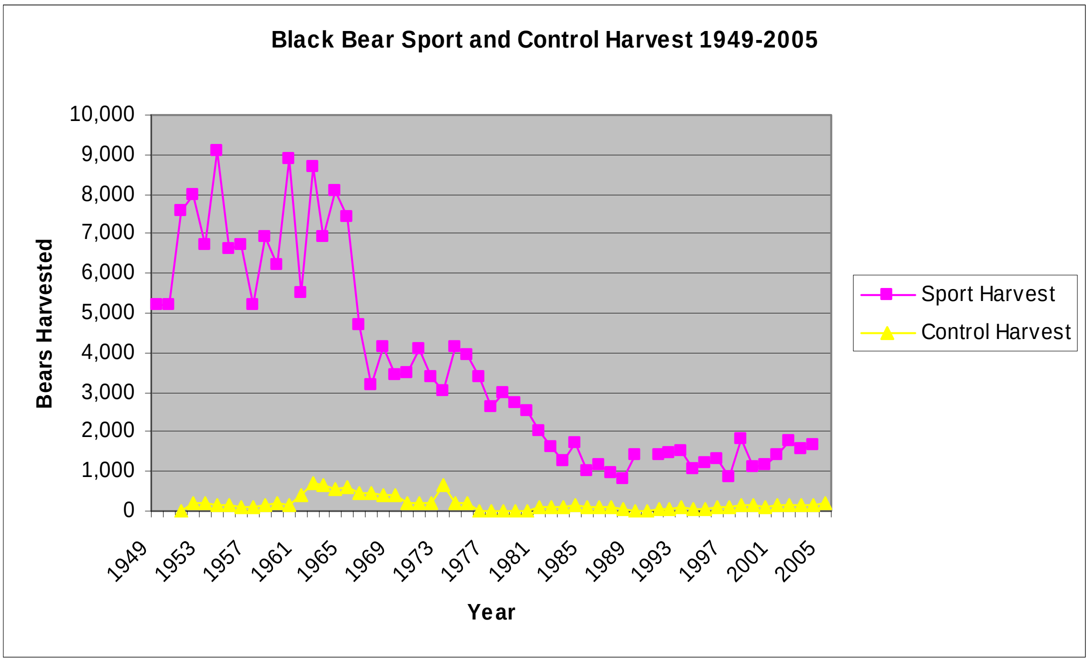

Fig 7.1: Black bear sport harvest as a population management tool in comparison to damage control efforts. Graph: Ziegltrum 2005

7.2.2 Black bear supplemental feeding

The ADCP stocked 900 feeding stations with approximately 500,000 metric tons of pellets over the last seven years annually. My field research showed six times less damage on feeding sites than on control sites just over four years (Fig. 7.2). Despite significant resistance, the black bear supplemental feeding program, used during mid

April to the end of June, is becoming more acceptable to the forest products industry in western Washington. The ADCP never promoted the practice of feeding bears, but more forest land mangers are using feeding stations today because of the proven success in the field, its cost effectiveness and the unobjectionable ecological impacts.

The major concern during the testing of the supplemental feeding program was the development of a pellet which had higher palatability than the trees' phloem but was not as sweet and desirable as the ripe berries. The bears' pellet feeding was expected to cease with the appearance of salmonberries and huckleberries since bears needed to naturally wean off the feeding stations (Ziegltrum 2004). This objective was reached in 1991when even full feeding stations in July provided no incentives for bears to continue feeding on pellets. The black bear spring supplemental feeding program will likely be continued on private industrial forest lands until more effective and publicly acceptable tools are found in the future (Fig. 7.3).

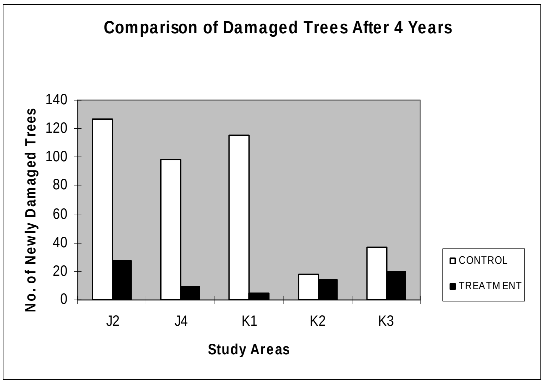

Fig. 7.2: Damage on feeding sites was six times less compared to control sites over four years. (Ziegltrum)

Fig. 7.3: Plastic black bear feeding stations as as used during the spring. Photo:Ziegltrum

7.2.3 Silvicultural methods to minimize black bear damage

The selection of silvicultural stand manipulations mostly depends on the individual objectives of land managers, available financial resources, and site characteristics. Preventative silvicultural bear damage strategies as currently used in western Washington consider the dietary choice of bears which select the most vigorous trees first.

Pre-commercially thinned Douglas-fir stands of 1000 trees/ha are more vulnerable than higher density stands. Lower density stands have higher photosynthesis rates, resulting in a higher concentration of up to 3.5% carbohydrates in the phloem (Fig. 7.4). Late and less aggressive thinning will reduce the amount of free floating sugars in the phloem and makes trees less vulnerable to the bears' feeding behavior. (Kimball et al. 1998) Bears seldom feed on shade tolerant tree species indicating that mixed stands with hemlock (*Tsuga* heterophylla) and western redcedar (*Thuja plicata*) may be beneficial. Exceptions are the rather homogenous hemlock stands along the Washington's coast which bears hit anyway because of no better alternative food sources. Fertilization also increases the trees' vigor, resulting in higher yields. This manipulation could be delayed or, where possible, not be implemented. Aggressive pruning will delay tree growth because fewer carbohydrates are produced in the needles. It also stimulates the production of terpene, which tastes bitter and therefore makes the phloem less palatable to bears. Highly productive, genetically altered trees with consequently high terpene levels may be more resistant to the bears' foraging behavior. Reforestations, 15 to 25-years-old which are lightly stocked and quite homogeneous in tree species composition and tree size are particularly vulnerable to black bear damage. The USDA Forest Service experiments with uneven aged, multi species tree stands to minimize bear tree girdling problems. Douglas-fir is a light dependant tree species and multi layered canopies may not favor the regeneration and growth of this species. Forest Service research results are depending. Bears often feed unpredictably and feeding choices - and therefore tree damage - depend often on alternative available food sources. Forbs and herbs, seeded along vulnerable tree stands and forest roads, may be desirable and minimize bear tree damage. However, no research was implemented so far to test the hypothesis.

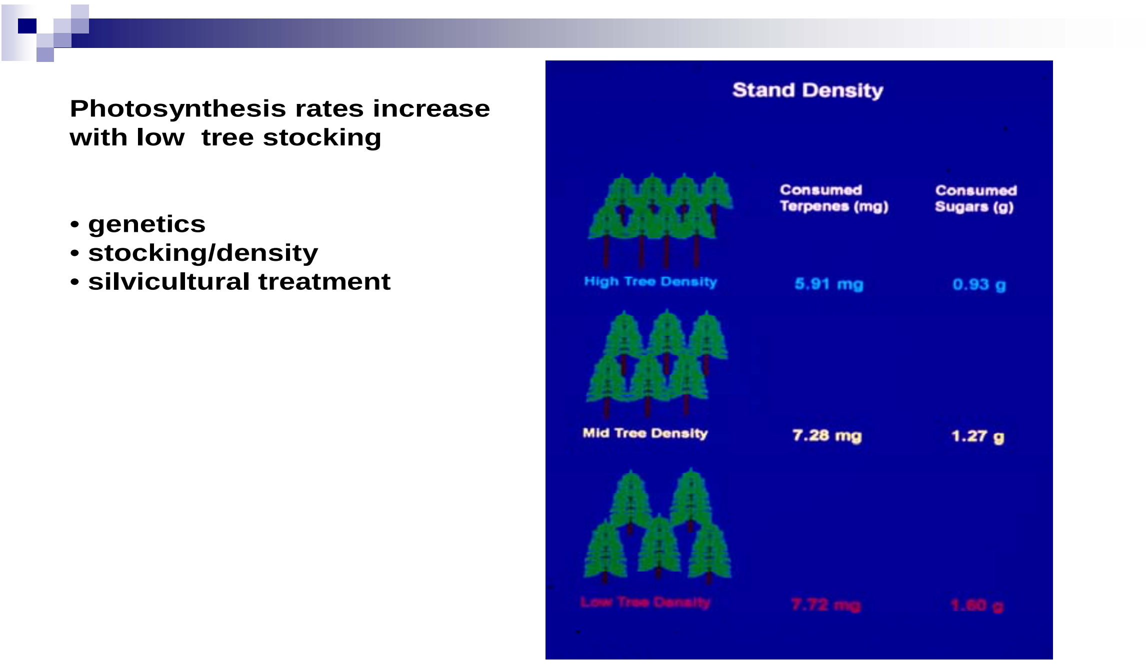

Fig. 7.4: Stand density in relation to sugar and terpene production in a tree. Print: USDA/APHIS.

The second and third growth conifer forests of Washington produce incomparably high yields but are highly manipulated. If private forest lands were to be managed to produce a spectrum of outputs – timber, wildlife, recreation, jobs – it would be necessary for resource managers to be proactive and develop resource management plans. These plans became reality in Washington State and are called Forest Practice Habitat Conservation Plans (FPHCP). Washington State legislators directed the

Washington Forest Practices Board in 1999 to work on rules to protect wildlife and fish habitats. Forest and fish rules were adopted in July of 2001 as a cooperative effort of state and federal agencies, counties, the Governor's office, private forest landowners, and the Washington tribes. All FPHCP were developed in cooperation with the USDA Fish and Wildlife Service and reviewed the ecology of one forest ownership. Contracts were signed for periods of 50 years to protect the viability of the forest products industry which makes long term investment decisions. FPHCP are binding for the landowner and the federal government.

The guiding principle of this new management strategy is to follow two of Commoner's laws of ecology: "everything is connected to everything else" and "there is no such thing as a free lunch" (Commoner 1971).

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