JACK PINE SEEDING STUDY
Second Year Results

Paul Berrang and Al Saberniak
December 12, 2005

Summary

Is direct seeding of jack pine an effective regeneration technique or a waste of seed? We evaluated its effectiveness on six sites on the Hiawatha National Forest. At five of the sites, direct seeding did not increase the number of seedlings. At one site, direct seeding was effective.

Introduction

Regeneration failures make it difficult for Forests to certify stands as fully stocked within 5 years of harvest as required by law. On the Hiawatha NF, most failures to regenerate jack pine are associated with direct seeding.

The Hiawatha sometimes has difficulty in obtaining enough seed to support their direct seeding program. This is in part because direct seeding of jack pine requires huge amounts of seed. The 4 ounces of seed that is used to direct seed one acre could reforest approximately 20 acres if it was grown as bareroot seedlings at a nursery and planted (assume 131,000 seeds/pound, 2 seeds/plantable seedling, plant 800 trees/acre). The effort involved in obtaining enough seed to support direct seeding is only justifiable if it is effective.

Another way to look at this is to compare the amount of seed applied in a direct seeding operation to the large amount of seed that should already exist on an acre of jack pine. A mature jack pine stand with serotinous cones can have as much as 13 pounds of seed per acre (Rudolph and Laidly 1990). This is 50 times as much as the 4 ounces of seed typically applied during direct seeding. Does the relatively small amount of seed added during direct seeding significantly increase the number of seedlings obtained at the time regeneration success is determined?

Cooley (1972) found that direct seeding of jack pine was very effective when the seed was applied directly to bare mineral soil after the site had been burned and deeply scarified with an Athens disk. The Hiawatha NF uses a less intensive site preparation (rollerchopping) and applies the seed on top of the snow in late spring. We don't know if direct seeding is effective under these conditions.

This document describes the first and second years of a study designed to evaluate the effectiveness of the Hiawatha NF approach to direct seeding of jack pine. We plan to collect additional data in future years.

Materials and Methods

Six sites on the Hiawatha NF that had been clearcut in either 2001 or 2002 with the intention of regenerating jack pine were selected for this study (Table 1). Two of the sites were on the Munising District and four were on the Sault Ste Marie District. All of these sites would have been direct seeded under the standard procedures now used on the Forest. All six sites received the same site preparation; they were double rollerchopped and chained in 2003. The number of trees left uncut varied considerably from site to site. The two Munising sites were prepared early in the summer of 2003 while the Sault Ste Marie sites were prepared late in the growing season.

The study was designed to compare two types of plots: ones that had been direct seeded and ones that had not. In fall of 2003, either 20 or 30 plot centers were established at each site. An arbitrary compass heading was chosen at each site that traversed the middle of the clearcut. An experienced technician walked the transect and chose plot centers at places where site preparation was judged adequate. After each plot center was chosen, the plot was randomly allocated to either the seeded or the non-seeded treatment with a coin toss. The only stipulation was that half of every set of ten consecutive plots would be allocated to the seeded treatment and half to the unseeded treatment. The distance between plot centers varied, but was about a chain (66 feet). The plots were laid out by Phil Kinney with help from Mark Vonderwerth, Al Saberniak, and Paul Berrang. Across all 6 sites, a total of 150 plots were established.

Seed was obtained from cones collected in timber sales on or nearby the Forest. Seed was applied to the seeded plots in spring of 2004 with a seeder attached to the back of a snowmobile. The seeding rate was 4 ounces/acre. This is the procedure normally used by the Forest to seed jack pine. Snowmobile operators were asked to not apply extra seed to seeded plots. They were asked to avoid non-seeded plots. Plots on the Munising District were seeded by Chuck Schwartz and Gerrad Carothers and those on the Sault Ste Marie District were seeded by Mark Vonderwerth and Mike Thibodeau.

After snowmelt in spring of 2004, the percentage of bare mineral soil exposed by site preparation was estimated for each plot. At this time, the number of jack pine cones on each plot was characterized as high, medium, or low and the number of pre-existing seedlings was counted. These estimates were done by Al Saberniak.

Table 1 – Stands chosen for jack pine seeding study.

District name	Compartment number	Stand number	Cutting reported	Number acres	Number plots
Munising	81	7	11/14/02	54	20
Munising	81	19	11/14/02	20	20
Sault Ste Marie	23	2	06/12/01	127	30
Sault Ste Marie	23	16	05/08/01	37	20
Sault Ste Marie	24	32	05/08/02	166	30
Sault Ste Marie	24	34	06/24/02	72	30

In fall of 2004 and fall of 2005, a 250th acre, circular (7.45 foot radius) plot was established around each plot center. All pine seedlings were counted in each plot. In 2004 each seedling was marked with a short flat plastic stake (a steak stake). During this year, most of the seedlings were very small, consisting of little more than the cotyledons and a tuft of primary needles. It was not possible to distinguish among species of pine. The 2004 data were collected by Kristi Keach, Mark Vonderwerth, Phil Kinney, Gerrad Carothers, Paul Berrang, and Al Saberniak. In 2005, the species of pine were recorded when possible. In this year, each seedling was marked with a small plastic tube (a coffee stirrer). These data were collected by Kristi Keach, Theresa Reilly, Mark Vonderwerth, Phil Kinney, Mike Thibodeau, Doug Born, Paul Berrang and Al Saberniak.

We plan to collect similar plot data in year 3 and possibly in year 5.

Results and Discussion

General observations. There were very few seedlings on the plots prior to seeding in the spring of 2004 (Table 2).

Full stocking in these stands would be about 800 trees per acre. Our expectations for this study were based on experience with operational regeneration surveys. Those surveys are generally not done until three years after seeding because it is thought to be too hard to see the seedlings during the first or second year. After three years, operational regeneration surveys generally show about one seedling in a 750th acre plot. Because of this we expected to find about 3 seedlings per a 250th acre plot. Instead, we found an average of 27 live pine seedlings per plot at the end of the 2004 growing season and 17 at the end of the 2005 growing season. There were substantial differences among the 6 sites in the average number of seedlings found after both growing seasons (Table 2).

Some of the stands in the Sault Ste Marie District had substantial numbers of mature red pine at the time they were seeded. We suspected that a substantial number of the seedlings counted in 2004 might turn out to be red pine. However, more than 99% of the seedlings that could be identified in 2005 were jack pine. Species was ignored during the analysis during both years.

Table 2 – Comparison of stands after one growing season.

District name	Compartment/ stand number	Average % bare soil	Average number live seedlings/plot		
			2003	2004	2005
Munising	81/7	34	2	18	22
Munising	81/19	42	1	11	12
Slt. Ste Marie	23/2	76	0	26	14
Slt. Ste Marie	23/16	63	0	11	8
Slt. Ste Marie	24/32	52	0	68	29
Slt. Ste Marie	24/34	51	0	30	21

Data and analysis. Typical analyses often include analysis of variance to determine if there are differences among treatments and correlation to determine if there are relationships between variables. Both of these techniques require that the data have a normal distribution (i.e. a bell-shaped curve). The data collected for this project were not normally distributed. This is often the case when data consist of counts. These data were analyzed using non-parametric techniques that do not require a normal distribution. These procedures analyze the ranks of plots rather than the number of seedlings per plots. The Kruskal-Wallis test was used to determine if there was a difference between the seeded plots and the unseeded plots and Spearman's rank correlation was used to find out if variables were related. All analyses were performed with SAS.

In the process of analyzing the second year data, an error was discovered in the analysis of the first year data. This caused some minor differences between the results for the first year that were shown in the last report and the results for the first year that are shown in this report.

Differences between treatments. Operationally, foresters want to know if there are enough seedlings to say that regeneration was successful. About 90% of the unseeded plots had 3 or more seedlings. This would suggest that direct seeding was not needed on these sites. However, the moist conditions during the 2004 growing season mean these data may not be representative of most years.

This study was set up to determine whether the number of seedlings in the seeded plots was different from the number of seedlings in the unseeded plots. In 2005, across all 6 sites and 150 plots, there was an average of 17 seedlings in the unseeded plots and 20 in the seeded plots (bottom line of Table 3). Are these two numbers different? This can be answered either statistically or biologically.

Table 3 – Average number of seedlings for seeded and unseeded plots during each of two years. The difference between seeded and unseeded plots in any one stand during any one year are significant only if they are followed by different letters.

District name	Compartment/ stand number	Number 2004		Number 2005	
		Seeded	Unseeded	Seeded	Unseeded
Munising	81/7	18 a	18 a	23 x	20 x
Munising	81/19	12 a	10 a	12 x	10 x
Slt. Ste Marie	23/2	29 a	23 a	17 x	11 x
Slt. Ste Marie	23/16	12 a	9 a	11 x	6 x
Slt. Ste Marie	24/32	65 a	70 a	24 x	34 x
Slt. Ste Marie	24/34	38 a	21 b	[illegible]	[illegible]
Across all 150 plots on all 6 sites		32	28	20	17

Statistically speaking, we can never say we are absolutely sure that two numbers are different. Instead, we say they are different with a certain level of confidence. The chance that we could find a difference this large across all 150 plots due to chance alone is 7%. Many biologists would say this difference is not statistically significant. However, given the variability of field data it seems more reasonable to say that, across all 6 sites, there is probably at least a weak difference between seeded plots and unseeded plots.

If we assume for the purposes of discussion that the difference between seeded plots and unseeded plots is statistically real what does it suggest for biological significance? A difference in 3 seedlings in the average 250th acre plot would be equivalent to a difference in 750 seedlings per acre. This is a substantial number of seedlings, but it likely would have been much lower in a year with less rainfall than we had in 2004. The 4 ounces of seed that was applied to each acre contained about 33,000 seeds. An increase of 750 seedlings per acre suggests that about 2% of the seed that was applied actually germinated and lived till the end of the second growing season. This is substantially more wasteful of seed than planting seedlings. We could expect about 50% of the seeds that were planted in a nursery to produce a plantable seedling after 2 years and we would expect about 80% of these seedlings to survive being planted. Another way to look at this is to compare the numbers of seedlings resulting from natural regeneration and direct seeding. If we chose to believe that the difference between seeded plots and unseeded plots is real, than about 85% of the seedlings on the seeded plots originated from seed that was in the stand at the time it was harvested.

Since regeneration success varied considerably from site to site, it would be interesting to know if seeding was more effective at some sites than others (Table 3). At 5 of the 6 sites, we were not able to say the two treatments differed. At these 5 sites, the difference between seeded and unseeded plots was not even close to being statistically significant. However, at one site near Raco, there were large and statistically significant differences between seeded and unseeded plots.

It is interesting to note that the site with the biggest difference between seeded and unseeded plots was not the site that had the highest number of seedlings per plot. We don't know why direct seeding was so much more effective at this one site than any of the others. Knowing why could be very important.

One explanation might be that the timing of harvests or site preparation could affect the effectiveness of direct seeding. For example, if site preparation was done well, but at a time that was not conducive to natural regeneration, it might be more likely to see a difference between seeded and unseeded plots. We don't have the information to evaluate this possibility for these plots. If the Forest were to record actual dates of harvest and site preparation in the future they may be able to assess the validity of this explanation.

Other considerations. Moist conditions during the 2004 growing season were probably responsible for the unexpectedly large number of seedlings counted in 2004. The results might have been much different if the year following seeding had been especially dry.

Rodents can consume large amounts of seed and large numbers of very young seedlings (Cote *et al.* 2003 and Ostfeld *et al.* 1997). We did not document seed or seedling consumption and its effects are unknown in this study.

Relationship between variables. We collected data on the amount of bare soil exposed on each plot and the number of cones on each because we thought these factors might affect the number of seedlings. Did they turn out to be important?

There were large differences among the 150 plots in the amount of mineral soil exposed by site preparation; it ranged from 10 to 95%. There were also large differences in the number of seedlings counted in 2004; they ranged from 1 to 183. Conventional wisdom would suggest that jack pine should germinate better on bare mineral soil than on undisturbed duff. In this study, the results were ambiguous. There was no correlation at all between the percentage of bare soil and the number of seedlings observed in 2004. However, the five plots with more than 100 seedlings in 2004 all had at least 65% bare soil. This would suggest that it is necessary to expose a whole lot of soil before seed germination increases, but five plots are not enough to say this with any confidence.

There were also large differences among the 150 plots in the percentage of seedlings counted in 2005 that were alive; it ranged from 6 to 100%. There was a significant negative correlation between the percentage of bare soil exposed and the percentage of seedlings that survived ($r = -0.33$, $P < 0.0001$). In other words, the percentage of live seedlings tends to go up as the percentage of bare soil goes down. Since 2005 was an especially dry and warm year, perhaps the slash acted like a mulch and helped retain soil moisture. In any case, we should not read too much into this relationship. In spite of being highly significant from the statistical point of view, only about 10% of the variation in survival is associated with variation in bare soil.

One would expect that plots with more cones would have more seedlings. In 2004 we compared the number of seedlings in plots with lots of cones to the number of seedlings in plots with relatively few cones. The differences were not at all significant.

Value of early data.

Forests are expected to certify stands as fully stocked within 5 years of logging. Sometimes one of the five years passes between logging and site preparation. The Hiawatha NF generally does not collect data on regeneration until 3 years after site preparation is complete. This is because some people believe regeneration does not develop for several years. The problem with waiting three years to collect data is that it is often too late to treat the site and improve stocking before the 5 year deadline.

These data indicate that substantial regeneration can occur during the first and second year after treatment. Does this mean data on regeneration should be collected during the first and second years? Perhaps, but we must remember that collecting regeneration data early is time consuming and expensive because the small seedlings are hard to see. There is no point in going to this expense unless the predictions made from it are reliable.

How well does data collected during the first year predict what happens at the end of five years? We won't know this until (and if) we collect five year data, but we can see how well year-one data predicts year-two data. The correlation between the number of live seedlings counted at the end of the first year and the total number of seedlings counted at the end of the second year is almost perfect ($r = 0.92$, $P < 0.0001$). However, 40% of the seedlings that were counted in the second year were dead. Variation due to mortality can affect the quality of predictions made from first year data. The correlation between the number of seedlings counted at the end of the first year and the number of live seedlings counted at the end of the second year is very good, but not perfect ($r = 0.75$, $P < 0.0001$).

Surprisingly, there is a weaker, but still powerful, negative correlation between the number of seedlings counted at the end of the first year and the percentage of live seedlings during the second year ($r = -0.28$, $P < 0.0004$). In other words, the plots with the largest number of seedlings the first year had the smallest percentage of live seedlings the second year. This indicates additional information is needed before we can justify using first year data to predict regeneration success.

Cited.

Cote, M., Ferron, J. and Gagnon, R. 2003. Impact of seed and seedling predation by small rodents on early regeneration establishment of black spruce. Can. J. For. Res. 33:2362-2371.

Cooley, J.H. 1972. Site preparation for jack pine on Grayling sands. Research Note NC-138. USDA Forest Service North Central Forest Expt. Stn., St. Paul, MN.

Ostfeld, R.S., Manson, R.H., and Canham, C.D. 1997. Effects of rodents on survival of tree seeds and seedlings invading old fields. Ecology 78: 1531-1542.

Rudloph, T.D. and Laidly, P.R. 1990. *Pinus banksiana* Lamb. Jack pine. In Burns, R.M. and Honkala, B.H. Silvics of North American. Vol. 1, Conifers. Ag. Hdbk. 654. USDA Forest Service, Washington DC.