

faced with the prospect -- explosives have become sort of fashionable among marsh managers. If you must use them, you had better learn the safe and effective procedures from an expert. I am an expert and I can prove it -- I am here, not a spook, able to talk to you without a medium or a seance.

The problem in using explosives is not to make mistakes. I want to tell you how not to make that first mistake. That may be the only one you're allowed.

For several years I have used Farmex ditching powder (40% gelatine, propagating dynamite) and explosive nitro-carbo-nitrate granules to build boat channels, pot-holes, and drainage ways in marshlands. In this, and only in this, narrow range of the many uses of explosives am I an expert. In this I have had personal field experience, and this is what I'm going to talk about. I can't blow stumps, mine gold, or crack rock for highway fill. I don't know how to handle nitroglycerine, blow safes, make booby traps or Molotov cocktails. And I never expect to learn. I'm content with knowing how to blow a marsh ditch cheaply, effectively, and safely. And I want to tell and to show you people how to do the same.

In the first place -- why use explosives? They are dangerous and noisy. And do they really do an effective job? A competent marsh manager uses explosives only where no other means of moving dirt will serve as well or as cheaply. If the terrain is too mucky or unstable to support heavy machinery; if the job is too small or too remote to justify transporting heavy equipment; if the marsh is permanently wet or inaccessible to vehicles; and, finally, if hand labor is scarce -- you have valid reasons to use explosives. But the explosives should be used only as a last choice, not as a first choice, tool.

Why? First, because of the very real hazard to personnel and, second, because of the limited precision in results. Both of these faults are not due to the unevenness of the explosive material, but due rather to human carelessness or miscalculation. One stick of dynamite of a given strength blows up just as forcefully as any other stick of the same listed strength. Where or how you place or time the stick -- these are the variables. And the reaction, the explosion, is always all or none. You can chip or change midway through an excavation with a shovel or a 'dozer, but once you push the plunger of a detonator it's too late to change your mind.

What about the cost? Dynamite is fairly expensive and the trained personnel to handle it draw pretty high wages. But draglines are costly, too, and heavy equipment operators also draw high wages. Once on the job, excavation with explosives costs as much as heavy equipment. The saving with explosives comes in getting a job set up; the logistics of spotting a dragline or a 'dozer ten miles out on a roadless swamp, as compared with putting a couple of men and box of explosives out there. The dragline mats out -- the

dynamiter walks out or takes a boat.

On the average, it costs a dollar to blow a ditch a yard long, eight feet wide, four feet deep -- a single-stick ditch. Farmex ditching powder costs \$18.25 for a fifty-pound case, \$36.50 per hundredweight. Propagating powder comes in half-pound sticks. To blow properly, they must be no more than eighteen inches apart. At this distance the shock wave from the explosion of the first stick detonates the second, the second the third, and so on like a domino train. So -- simple calculation: one pound to the yard; a hundred yards take a hundred pounds of dynamite; powder costs are about 37 cents a yard. Other material -- wire, detonator (purchase or rental), fuses, etc., -- bring the cost of materials to about 40¢ per yard for a single-stick ditch. In hard, dry, or heavily vegetated ground where two, three, or four sticks and/or double lines may have to be used costs go up, of course.

Labor runs whatever the market will pay. I charge from \$75.00 to \$100.00 per day for this work, if there is an extensive contract. My charges are higher for a one- or two-day job. A professional powder-monkey will charge about \$60.00 per day, but he requires extra labor and supervision. In a soggy marsh, I can usually make small ditches as cheaply and as neatly as a dragline.

For those of you who work or will work for a state or federal agency, labor costs may not be an item. Many of you will serve as your own powder-monkey; your material costs will be all you have to consider. Incidentally, how much ditching can a two-man team do in a day? If the terrain is tough and the area hard to reach, a hundred yards may be a good day's work. When everything has worked just right and the ditch runs have been long, I have done four hundred yards in one day, easily; and once six hundred -- but that was a back-breaker.

Legally, who can use explosives? Regulations vary from state to state and, in California, from county to county. The State of California has no licensing regulations. In most counties regulation is under the county fire department. You simply apply to the County Fire Marshal, filling out a form attesting that you are qualified and responsible and listing the vehicle you will use to transport the explosive. Small quantities (up to six hundred pounds) require no special vehicle, but each vehicle must be grounded and must contain a fire extinguisher. Large quantities must be transported by qualified and marked carriers. Such transport is usually arranged through the retail supplier.

Storage on the job is simple if you store only what you will use promptly. A dozen boxes loosely stacked on a wooden platform and covered with a tarpaulin will stay cool, dry, and perfectly safe out in the open in the

marsh -- providing some idiot with a rifle doesn't shoot into the pile. Store the dynamite away from dwellings or other buildings, or from places where kids or stock can get into it. Keep a record of the explosives on hand. Do not let economy override your judgment so that you try to save or store a half-box of unused dynamite. Detonate what you don't use. Fuses, in a proper container, can be stored safely for six months. Caps don't sweat, but copper does corrode in time. So, if the six months extend to a year get rid of the caps -- and that means detonate them, don't just toss them on the dump. Lots of little kiddies are minus eyes or fingers because of pretty little copper firecrackers they found and hit with a hammer!

O.K. You're legally qualified to handle dynamite and you've decided to blow a ditch. What do you need? You need:

- another man to help you
- dynamite
- detonating caps in a safe case
- a wooden dibble or charging stick
- a digging bar (possibly)
- a bundle of four-foot laths to use as marking stakes
- a ten-cap magneto detonator and about three hundred yards of detonator wire
- a wooden fusing awl
- a knife
- canvas knapsacks to carry the gear and materials
- bright plastic marking tape to mark it all.

It is very easy to drop a detonator or a knapsack full of dynamite and then have to hunt like hell for forty-five minutes in head-high tules to find it. A bright red ribbon helps.

These are the basics you will need to go ditch-blasting. These, plus a certain amount of experience and a philosophy concerning the use of explosives. The philosophy is this: "Don't be afraid of the stuff -- and never, never get over being afraid of it". This apparent contradiction is simple. If you are too nervous and tense you'll make a mistake; if you get overconfident and careless you'll make a mistake. One mistake is all it takes -- the first one can easily be the last.

Do everything by the book, by rote -- or as we used to say in the army "by the numbers". Work out a detailed sequence of activities for transporting the explosive, placing the charges, and firing the shot. Never deviate from this routine -- it must become a habit or you can be killed. If your helper is stupid or careless, you can be killed. There is room for only one boss on the job and every order must be followed precisely, or you can be killed.

Now, if I've scared you all enough to be sure of your attention, I'll show you how to set charges. Actually, dynamite is amazingly safe and stable. Sticks of dynamite can be dropped, scuffed, pounded, and burned with near-impunity. It takes a fuse with the foot-pounds of force equivalent to a shotgun shell to detonate it. Only when the stick of powder is fused is it really dangerous, and then only because of the fuse.

All fuses or dynamite caps are little copper cylinders (sort of a copper firecracker) containing a small amount of unstable explosive, like fulminate of mercury. There are two main kinds of caps: some are ignited by a burning cable or wick; others are detonated by an electric charge passed through conducting wires. I use only electric caps. The reason -- when you light a fire fuse you are committed, you have only a limited time to clear the danger zone before the charge goes off. With electric caps, you can change your mind right up to the moment of explosion, the moment when you twist the plunger of the detonator.

Electric caps (fuses) are the really dangerous items in this work. Keep caps in a stout wooden box, well marked and well padded. I use a wooden army surplus .30 caliber ammunition case that I've lined with sponge rubber. Keep the box away from fire, direct sunlight, and from electric currents. Each cap has a pair of lead wires. I use ten to twelve-foot leads. These leads are to be kept crossed and shorted at all times. There is a small metal clip on each pair of leads. DO NOT REMOVE THIS CLIP until the shorted detonator lead is connected. An unshorted or gapped cap lead can act like a radio antenna and a shortwave radio impulse can set off the cap. The odds against this happening would seem astronomical -- the wire must be gapped and pointed just right to pick up the wave frequency and the source has to be close enough to carry a strong impulse. But a man whom I trained neglected once upon a time to check the shorts on his caps. A Standard Oil truck drove into the marsh to check a gas well and then called the office on shortwave radio. Luckily, the dynamiter had followed the rest of my procedures -- he and the dynamite and the fuses were in separate places. Only the knapsack with the fuses blew up, not the dynamite with the man. This guy just had the nervous trots for the rest of the day.

Store and transport the dynamite in the box it comes in. But before you accept the box from the supplier make sure, by opening each carton, that the powder is fresh and firm. Frozen, overheated, or aged dynamite may have the liquid nitro sweated or settled out of it in crystals or in syrup-like globules. And if you even look crosseyed at stuff like that it can detonate. Never use aged, frozen or overheated explosive.

A typical marsh dynamiting job can be one like this: you need to blow a ditch four feet deep and eight feet wide, extending for a hundred yards from a deep slough to a shallow pond -- a boat channel or a drainage ditch across

a soggy marsh. The plant cover is a mixture of salt grass, pickleweed, and alkali bulrush. A dense mat of Olney bulrush borders the deep slough. Cattails border the pond. The soil is mucky peat and clay.

The foregoing factors tell you that you need a single-stick charge set on a twenty-four inch base. The heavy mats of vegetation at the ditch ends, and the need to provide space for boat turnarounds, require that the ditch ends be double-charged. At a 24 inch depth the charges will be standing in water. They will not have to be tamped and they will propagate well on 18-inch spacing. You will need, then, about 125 pounds of explosive for the job -- one hundred pounds for the run and fifty half-pound sticks for the reinforced charges at the ends.

A stake is set at the slough's edge and the roll of lead wire is tied and paced out to the pond's edge. If there is any choice, try to situate the ditch across the prevailing wind. A strong wind helps to divert fall-back of muck and clods from the ditch. On the other hand, a wind straight down the ditch could result in enough fall-back to justify scrubbing the project until a calm day.

The dynamiter, using the marked charge stake, now drills holes 18 inches apart along the line. Since the ground is mucky, this is fairly easy. The helper carries the powder and sets the charges loosely in the shot holes. At the end of the run, the helper reels up the lead wire for use in the detonation, while the dynamiter positions the charges to the desired depth. The charge is slipped into the hole and rammed gently down to the 16-inch mark on the stake; the bottom 8 inches of this 2-foot hole is thus filled with dynamite.

It is important to have the charges on the same level in relation to each other, regardless of variations in ground surface. To detonate propagating explosive, the shock wave has to jar the adjacent stick. Misfires are often caused by sticks out of position. And it is a nervous, dirty job to re-fuse and re-fire a half-shot ditch.

All the dynamite charges are now set except for the fused charge. The extra holes at the turnaround are set; double charges may have been set through the Olney bulrush mat; and your helper has strung the two or three hundred yards of lead wire upwind from the ditch. This lead wire has been crossed and shorted at both ends.

The cap is brought up. The helper moves to the firing station at the end of the lead wire. You are ready to fuse and set the firing charge. With your wooden awl drill a hole in the end of a stick. Carefully and gently insert the copper cap and re-crimp the waxed paper of the charge around the lead wires. Tie two half-hitches around the stick and lower the charge,

capped end first, into the charge hole. Position with the charge stick. Please, do not ram down hard or beat on this fused charge! The half-hitches on the fuse wire keep strain off the cap and keep it from pulling free. Now twist the fuse lead wires to the detonator leads. These connections are bare, so they must be kept apart and off the damp ground, to avoid short-outs. Hook them to a stake or a convenient bush.

Now, and only now, do you remove the aluminum short-out clip from the cap lead. The charge is connected and ready to fire, except for the short at the firing terminal. As you leave the area do not trip over the lead wire -- the pesky thing will get underfoot. Take the detonator from its case, unshort the end wire, attach to the detonator poles, take one final look around to see that all is clear, yell "Fire! Fire in the hole!" and twist the handle. And one hundred pounds of dynamite throws tons of muck and clods in the air.

Do not turn your back on the explosion. Two or three hundred yards is normally safe clearance, but an occasional clod may get an extra push. You can see it coming lazily down, like a high fly in baseball. Move smoothly and slowly out of its way. Do not take your eyes off it and do not panic and run. You stand a chance of running into a high flyer. And a chunk of muck the size of a bucket falling from three hundred feet could drive you down like a stake. The same guy that had the adventure with the caps -- this man really shouldn't have been using explosive! -- used to hold a shovel over his head and turn his back. Once a lump of muck about the size of a softball clobbered him right between the shoulder blades and he dropped like a rag. Luckily, it just knocked the wind out of him but it could have killed him.

After the explosion, having ducked any high flies, disconnect the detonator leads and short them out. This is an imperative safety step. Wait to roll up the wire and inspect the job until the gas and fumes from the explosion have drifted away. Dynamite fumes are poisonous -- the least effect is a splitting headache. If you do develop one of these ferocious headaches, don't drink any whisky that evening or you'll think your skull is cracked.

Suppose the explosion doesn't come off quite as you hoped. You have a misfire or some other boo-boo. What do you do? Don't hit the panic button; wait a while. Then carefully check your connections to the detonator and try the exploder again. Still no boom -- disconnect the detonator. Short the lead wire! Then you, alone, walk back along the lead line looking for a crossover short or a break in the line. Check all connections out to the cap lead. Hike back and try the detonation once more. If the misfire still holds, disconnect the detonator and short out the lead line at both ends. Short out the fuse charge and disconnect from the lead line. Drill another hole and set a new fused charge. Do not touch or disturb the sleeper. Use

even greater care inserting the cap and charge and prepare again to detonate. If it doesn't work this time, you have either a batch of damaged caps or a faulty detonator. Check the detonator by exploding a cap alone. Use care with the cap explosion; they go off like a shotgun and can throw copper shrapnel several feet.

Propagating powder will explode readily even after being in a wet hole for twenty-four hours, so you have time to leave the charged holes, if necessary, while you get a fresh supply of caps and another detonator from your supplier. However, in many years I've never had a bad cap or a faulty detonator. You probably won't either. I always found the trouble in a misfire to be a short or a break in the line.

You may occasionally have an incomplete propagation. This is always a mess and is your own fault. You skipped charging a shot-hole or you mispositioned a charge. Sometimes, when you are running short of powder, you'll get stingy and start spacing 24 inches or maybe even 30 inches, and then you'll get well deserved incompletes. You treat incompletes as regular shots, except you will also have to charge the ditch lip or shot berm, to throw out the extra over-burden flipped over by the incomplete. And in this over-burden you'll occasionally come on nuggets of non-fired dynamite -- sticks that didn't go off. Gather them up and stuff them where they'll detonate next time. Do not just leave the stray explosive there for some duck hunter to trip over.

Besides ditching powder, there are a couple of other explosives used in marsh management. One is a rope-like explosive, Primacord. It is widely used in military demolition but I have found only limited use for it in marsh management. The other explosive, one that I've used often, is a granulated nitrogenous fertilizer, nitro-carbo-nitrate, soaked with diesel oil. This substance is commercially sold under the trade name Nitrocarbomate, as well as other brand names. It costs about a third as much as Farmex. The explosive force is the same, pound for pound. Nitro-carbo-nitrate is not propagating, nor is it contained in handy sticks, and it is not waterproof. Consequently, some special handling and fusing techniques must be used.

In northwestern United States, nitro-carbo-nitrate has been used widely for pot-holing overgrown nesting marshes. The method is described as follows: The explosive is packaged in a plastic bag; an electric cap is tucked inside and the mouth of the bag is taped shut around the wires. The seal often leaks around the wires and then the charge may misfire. I've invented a simple solution for these misfires -- the nitro-carbo-nitrate sausage with a dynamite wienie inside. A truck inner tube is cut in two; one end is folded over and wired shut; twenty to thirty pounds of granules are stuffed inside; a stick of propagating powder is tucked in; the open end of the inner tube sausage is then folded over and wired tight. These charges can be left under

water for eight hours and will still detonate. To fuse, simply run a string of Farmex sticks from the sausage to a convenient spot; cap a charge and explode the line. The stick inside the sausage blows with the propagating shock wave and detonates the massive charge of nitro-carbo-nitrate. This method is particularly useful for clearing mucky pot-holes, blowing out floating mats, and so on. The sausage can be strapped to a long stake and positioned at the best depth in a muck hole or pond, without the danger of the charge floating free. A fused stick can be strapped to the outside of the sausage; the wienie inside is insurance against a misfire. The old inner tubes are cheap or free for the scrounging. Check the old rubber for leaks, naturally. Plastic bags could be used but the rubber is not only cheaper but also tougher, less liable to be punctured accidentally.

This about tells the story. I've told you something of the dangers and techniques used in handling marsh explosives. I've described a typical ditching operation and the use of nitro-carbo-nitrate in pot-holing. Time will not permit a full description of all possible techniques -- methods of getting "directional" blasts; use of Primacord; piped charges, and so on. As your own experience broadens, you will undoubtedly work out techniques of your own, as I did with the "sausage".

All of you should, in your first field experience, work with an expert. Ask questions and do not smart-aleck with explosive. Dynamite has absolutely no sense of humor. Recognize the limitations of explosives. A bulldozer, a backhoe, or a dragline will do a more precise job than the best powder-monkey -- where the equipment can work. But explosives, like a 'dozer, shovels, trucks, or fire, are among the tools that every competent wildlife manager should know how to use.

And finally, once again, words of the gospel: "Don't be afraid, and don't ever quit being afraid" and "Do it by the numbers!"