Growth and Decline of Religious and Subcultural Groups

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Abstract

Within any population there are subcultural groups, based on religion, political belief, or lifestyle, which hold the allegiance of people. Often such groups include membership of an organisation such as a church, cult, political party, or some looser group that encourages the beliefs and practices of the subculture. These groups may survive for many generations, before eventually dying out. Many remain small minorities with little potential for growth. However a small number not only flourish, but eventually influence the bulk of society. A prime example of a successful group is the Christian church which, having grown for two millennia, is well poised to continue growing in the future, except in Western Europe where it still declines.

This paper examines the dynamics of the growth of such religious and subcultural groups and attempts to explain, using system dynamics, the causes of their growth and decline. Based on a mathematical model of church growth, published by the author, a systems dynamics model is developed incorporating births, deaths, and reversion. It is argued that the primary cause of growth is the existence of enthusiasts within the group who spread the belief, and hence recruit, through contact with unbelievers. It is further argued that growth is limited because they are only enthusiastic for a limited length of time, falling back to ordinary members of the group, with virtually no recruitment potential.

The model is applied to the spread of the Christian church and other subcultural groups, discussing their potential for long-term survival.

Readers who are unfamiliar with Systems Dynamics, but who wish to learn the methodology in order to understand the models, are directed to the technical reports Hayward (2000). These are a fuller version of this paper with an introduction to the methodology of System Dynamics.

1 Introduction

The growth of human populations has been extensively modelled from both a systems and a mathematical viewpoint. The processes of births, deaths, immigration and emigration are standard text-book models. However within the human population there exist subcultures which possess some features that distinguish them from the remainder of the population. Foremost among these are religious groups represented by churches, sects and cults which can have very rigid boundaries separating them from the rest of society. Other subcultures could include political groups, or more diffuse lifestyle groups such as vegetarians, youth subcultures such as punks, a hobbies society or even mobile phone users.

The dynamics of these subgroups differ from a standard human population in that they can recruit from a population of people who have yet to possess the features of the subgroup. In the case of a church there is an explicit desire to actively recruit, called conversion, from the rest of the population. For lifestyle groups, such as vegetarians, that desire to see others like themselves is purely at the individual level, or may not exist at all. However the lifestyle may prove attractive to others so that they also convert and become part of the group. Such conversion is very common amongst youth sub-cultures where there is a desire to be like their radical peers and different from an older generation.

Thus religious and subcultural groups have the conversion process as a significant part of its dynamics. This needs to be balanced out by reversion, those who give up the church or lifestyle. In addition it is possible to be born into such subgroups. Churches gain a lot of their recruitment from the children of those already in the church. It is possible that the children of vegetarians are more likely to become vegetarian themselves. However in the case of youth subcultures the reverse is often the case and children are more likely to abandon the culture of their parents. Thus births (and deaths) also play a part in the dynamics of religious and subcultural groups.

In the last thirty years a considerable amount of effort has been expended in attempting to understand why and how churches grow or decline. Much of the work is qualitative in nature usually giving recommendations to a church as to how it may improve its growth. (Gibbs 1981, Pointer 1987, Schwartz 1998 are typical examples). However quantitative measures of growth are also important and much attendance and membership data are produced (e.g. Brierley 1999a). Any modelling of the growth process is limited to statistical analysis or numerical arguments (Stark 1996). However in Hayward (1995 & 1999) a church growth model was developed using mathematical population modelling. The model, based on the general epidemic model, was constructed on two principles:

1. conversion growth of the church comes from contact between unbelievers and active believers, called enthusiasts;

2. enthusiasts only hold their enthusiasm, or potential for converting others, for a limited length of time after which they become inactive, but are still part of the church.

The model exhibited growth behaviour very similar to that seen in a religious revival, where the growth runs out because there are insufficient enthusiasts to maintain the level of conversion among a dwindling number of unbelievers. The result is that the growth ceases without all the unbelievers being converted. Indeed there is a threshold that the number of unbelievers must be above for significant growth to take place. That threshold depends only on the number of people that an enthusiast is responsible for converting during their enthusiastic phase.

The purposes of this current paper are to re-express the model in a systems format in order to understand the dynamics of the conversion process more fully, and to include effects of births, deaths and reversion. By taking a systems approach it is hoped that the behaviour can be understood without the need for extensive mathematical analysis. In addition, as outlined above, the model can be applied to subcultural groups other than churches and thus may be of interest to a wider audience. Although it will be constructed with churches in mind, other applications will be alluded to.

The paper is organised into two separate models. The first (Ch. 2) looks at the conversion process where the enthusiasts who are responsible for the conversion process retain that enthusiasm throughout their lifetime. The second (Ch. 3) then adds in the feature that enthusiasts only have conversion potential for a limited time span. Both will add births, deaths and reversion. It is hoped that this approach will make the effects of the different processes clearer.

A fuller version of this paper is available in three technical reports (Hayward 2000), available at the author's research website (Church Growth Modelling Website).

2 Unlimited Enthusiasm Church Growth Model

2.1 Conversion Model

2.1.1 Believers and Unbelievers

A church is a collection of people who have common religious beliefs, a common identity, and who meet together regularly, usually for worship. As such they are an identifiable subgroup of society, including those who are like-minded, but largely excluding those who have no part of that religious life. Thus, at the simplest level, it is possible to split society up into two groups: those who belong to the church - called believers, and those who don't - called unbelievers.

2.1.2 Conversion Through Contact

In addition the believers have a common mission, which is to see unbelievers become believers. Effectively this means recruiting people into the church, called conversion. For simplicity such conversion will be deemed to be a one-way process, thus there is a drain from the unbelievers to the believers over time, with no other losses to the system. The model is thus a two compartment model with transfer from unbelievers to believers (figure 1).

As was argued in Hayward 1999, the primary means of recruitment is through contact between an unbeliever and a believer. The contact itself may be the actual means of conversion, or it may be an invite to a meeting where the conversion occurs. Although many of these contacts occur between people who know each other, nevertheless it is possible that a believer's word of mouth testimony could inspire those they do not believe to seek out the church and become a believer. This is a common feature during times of religious revival where those affected by the revival are noticeably enthusiastic.

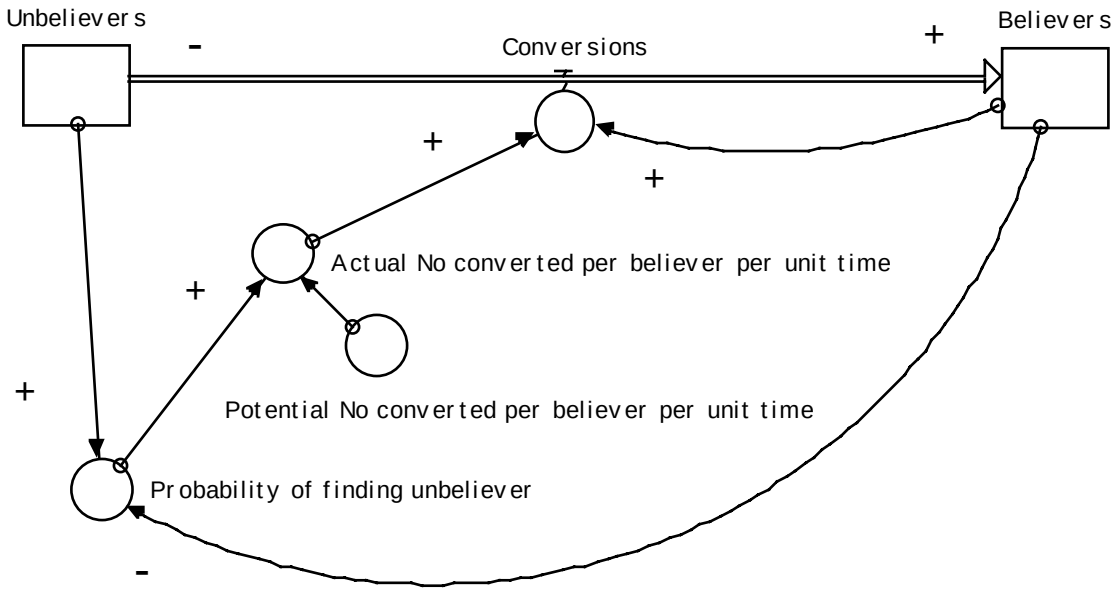

Fig. 1. Unlimited enthusiasm model of church growth

The number of conversions each believer is responsible for will depend on the probability of such a contact. Assuming that believers and unbelievers are homogeneously mixed in a population, this probability will be the fraction of the population who are unbelievers. Homogenous mixing means the church has to be geographically spread, rather than confined to certain places. This would be true for much of the history of Christianity, apart from when it was introduced to a country. Even in its early years Christianity became spread throughout the Mediterranean world quickly due to good transportation between major cities.

Thus the conversion rate (the flow rate *Conversions* in figure 1) is proportional to the probability of finding an unbeliever and the number of believers. The more believers there are, the more contacts with unbelievers take place.

One final assumption concerning the conversion process is needed. The believers do not cease recruiting unbelievers. Thus they do not run out of evangelistic zeal, or run out of unbelieving contacts before the pool of unbelievers is exhausted.

Thus, leaving out the effects of births, deaths and reversion the unlimited enthusiasm church growth model based on conversion is give in figure 1.

The potential number converted per believer (or conversion potential) is the number of unbelievers a believer could convert if all their contacts were with unbelievers. Of course the actual number will get lower as the church grows because more of their contacts are with believers. This tends to be true of churches as much of a believer's time is spent interacting with those who are like minded, so less of their time is spent recruiting unbelievers. The same is true of youth cultures and lifestyle groups. Vegetarians may influence other people to become vegetarian at a shared meal. However the more vegetarians there are at the meal the less people there are to influence.

2.1.3 Analysis

If the population of unbelievers is large in comparison to the believers, then growth of the church is initially exponential. At some point however the growth slows down and eventually ceases when the whole of the population has been converted. This occurs because the efforts of the believers are increasingly "wasted" on other believers as the number of potential converts declines. In the early period a single believer may know, or come into contact, with many believers, but as the church grows and the pool of unbelievers declines that believer will know fewer unbelievers.

This can be seen be examining the causal loop diagram for the model as in figure 2. This is an example of shifting loop dominance and results in the S-shaped, or logistic, growth of the believing population. A sample simulation (figure 3) shows this logistic curve.

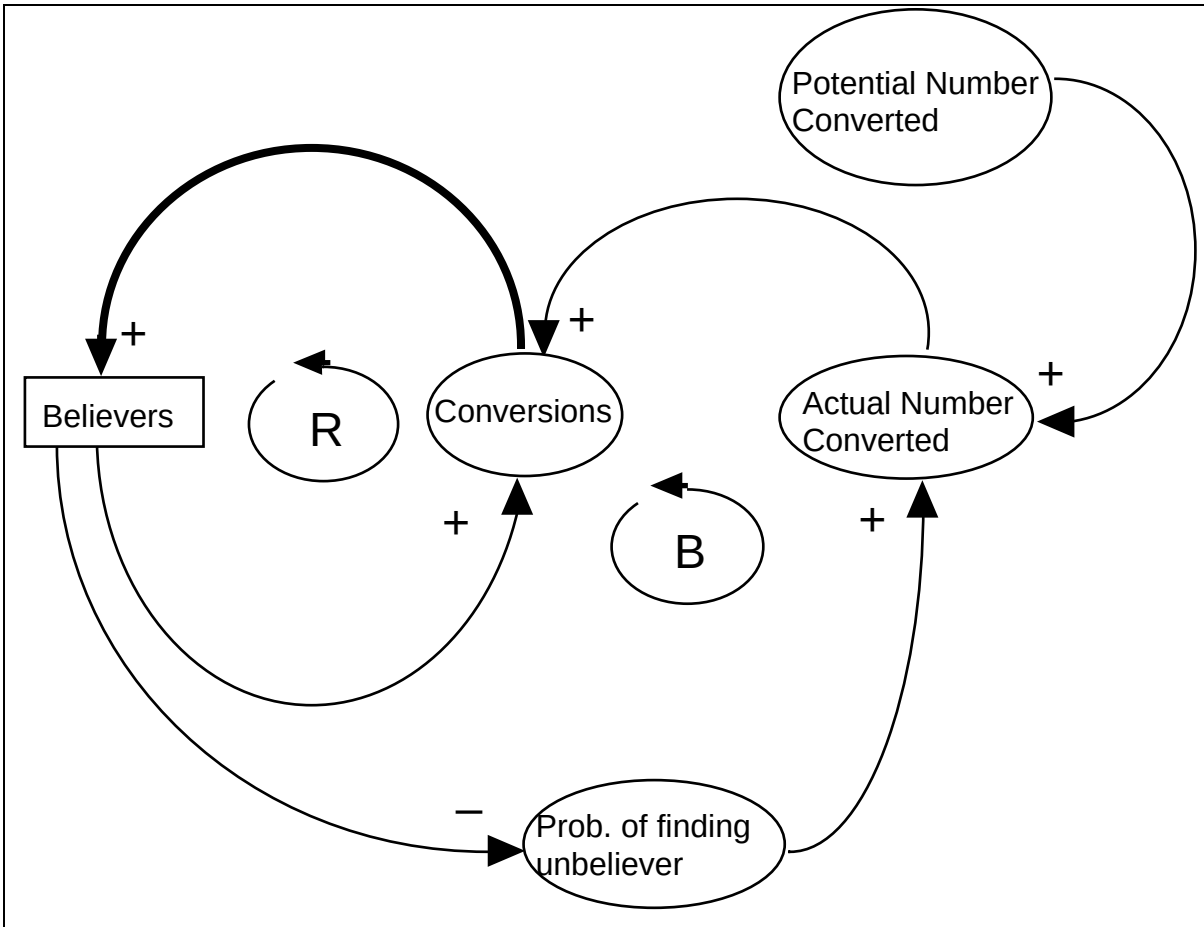

Fig. 2. Causal loop diagram of the unlimited enthusiasm model of church growth

In mathematical terms this is sometimes referred to as the simple epidemic model (Hayward 1999). However the model as it is presented here will be called the unlimited enthusiasm church growth model. It can be shown mathematically that the model results is the logistic equation (Hayward 1999), where the logistic limit is the total number of people in the population. The model is often used for the dispersal of innovations through a population, the so called Fisher-Pry models (Kumar et al 1992). A similar model was used by Coleman (1964), and Bartholomew (1982) for diffusion of social phenomena.

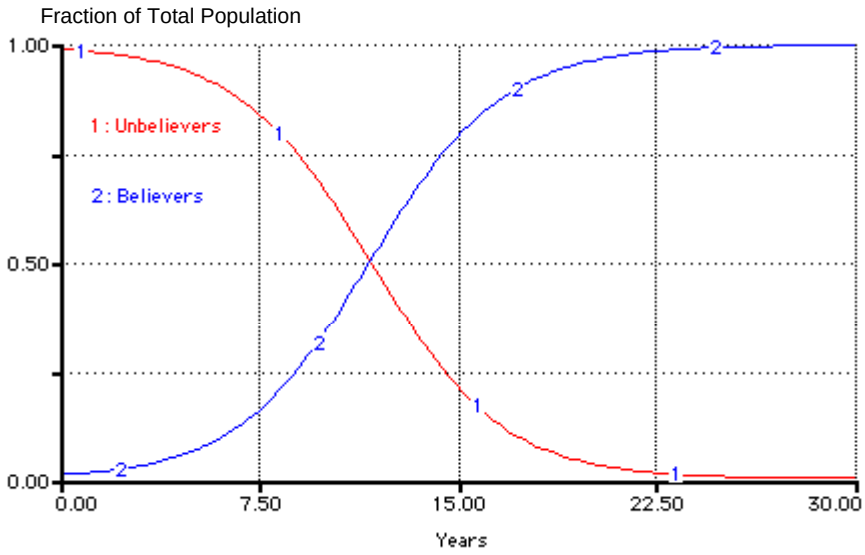

Fig. 3. Growth of the church through conversion with unlimited enthusiasm only

The time taken for the population to be converted depends on the initial numbers of believers and unbelievers, and also on the potential number of converts per believer per unit time. In this simulation the initial percentage of believers was 1%, and the potential number of people converted per believer per year was 0.4. That is each believer has had two contacts in five years that has led to a conversion. This results in the conversion of 99% of the population in just over 20 years. Such dramatic growth seems surprising from such a small conversion potential. The reason is that each convert also makes converts at the same rate, and does so indefinitely. To simulate more realistic church growth these assumptions will need to be challenged.

This S-shaped growth is typical of the type of growth seen in religious revivals. A point comes when the growth of the church explodes because there are so many enthusiasts whose contacts are resulting in the conversion of unbelievers, many of whom also become enthusiasts. Such behaviour can be seen in the Welsh revival of 1904, where 100,000 people were converted in just over a year. Likewise the current revival in South America is seeing explosive growth. Nevertheless no revival, however powerful, has ever resulted in the conversion of a whole population. Thus some changes to the model are required.

The bulk of the conversions occur in the middle period of the growth. Thus early on in the growth there are few contacts, and thus few conversions, because the percentage of unbelievers is so small. Because growth is the main factor through which revivals are first noticed it can mean that a revival can be underway some time before it comes to the attention of the population at large. This was true of the early Christian church which remained small for the first 200 years. E.g. only 1% of the city of Rome was Christian about 250 AD. Yet by 300 AD the church was so widespread that further persecution by the still pagan state became impossible (Stark 1996). Similarly in Egypt estimates of the size of the Christian church based on inscriptions of Christian names shows similar early slow growth followed by later rapid growth (Bagnall1982).

Likewise the growth of a fashion or subculture follows similar lines. The fashion for long hair among males, which started in the 1960's was for a long time only possessed by a minority.

Yet within a decade the fashion was widespread throughout western society, so much so that young people rebelled and adopted a different fashion! The adoption of colour TV's has followed a similar pattern and there is every expectation that the adoption of mobile phones will follow suit.

2.2 Unlimited Enthusiasm with Births, Deaths.

2.2.1 Births and Deaths

Introducing births into the model demands a question. Are those born in the same category of people as their parents? That is, are the children of believers automatically believers, and those of unbelievers automatically unbelievers? Clearly a child is not born with a religious belief. However if a child is brought up in the faith and subsequently adopts that faith while still in childhood, or adolescence, then they will be regarded as being born as believers. This is often called biological growth to distinguish it from conversion growth. Such children are not converted into the church having been an unbeliever.

Recognising the fact that not all the children of believers will become believers then a parameter, representing the fraction of children of believers who are born believers, is introduced.

Deaths are more straightforward, providing we assume that believers and unbelievers die at the same rate. Of course if the church is being persecuted it may have a higher death rate. If the "believers" are vegetarians they may live longer (or shorter!). If the subculture is of drug users then the death rate may be higher than the rest of the population. For this paper it is assumed all death rates are the same.

Figures 4 and 5 show the birth and death processes on the two population categories, with the conversion process suppressed.

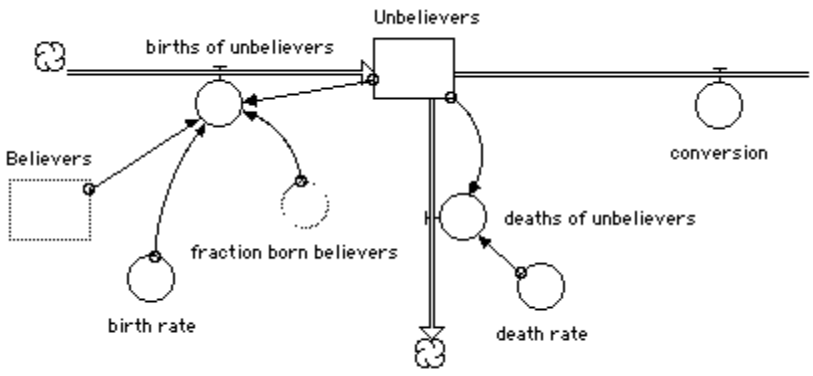

Fig. 4. Dependence on birth and death rates for unbelievers

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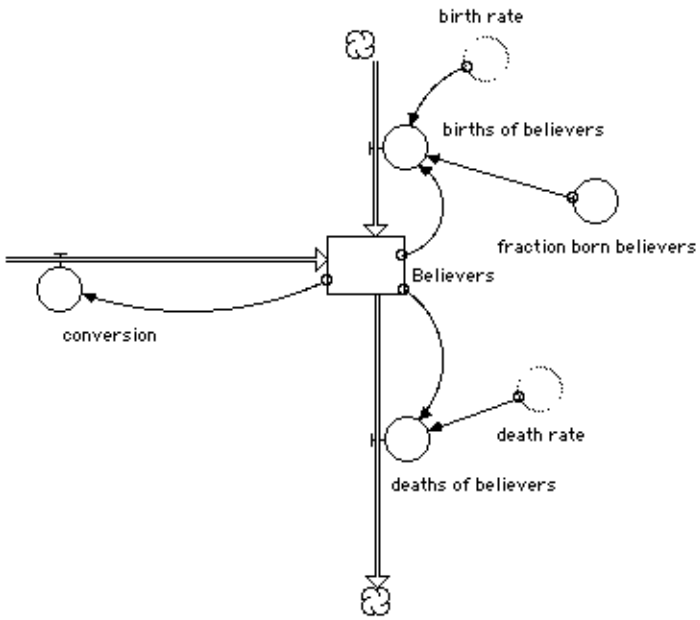

Fig. 5. Dependence on birth and death rates for believers

Note that the believers now have an additional balancing loop due to deaths which is either equal or larger in effect than the reinforcing loop due to births, thus giving a net balancing effect.

2.2.2 Analysis

Consider the case where the birth and death rates are equal, so that there is no change in the total population. The solution can be investigated for different fractions born believers, as in figure 6. The solution is still S-shaped.

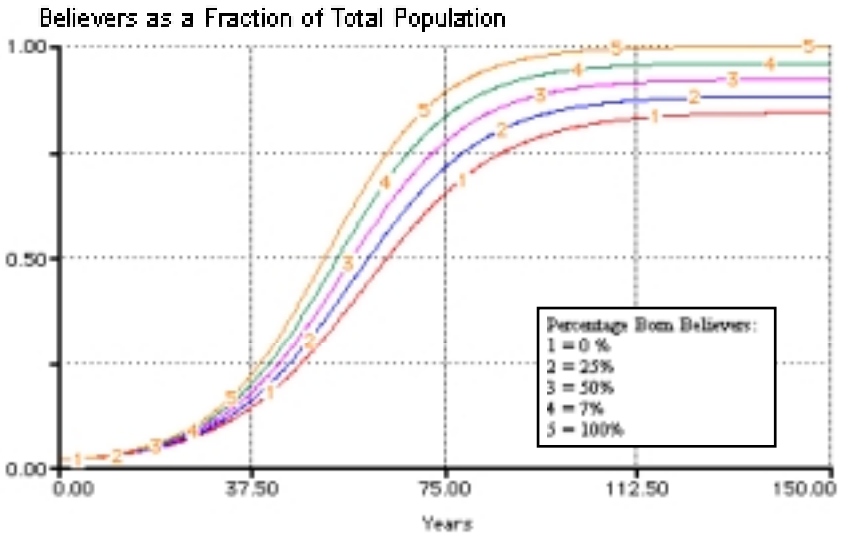

Fig. 6. Growth of church for different fractions born as believers
Number of converts per believer per unit time = 0.09

Thus whatever the fraction of children kept by the church, the population of believers increases to a stable fixed value. However the whole population is no longer converted unless all the children of believers become believers themselves. Anything less and the church can only grow to a value less than 100% of the whole population, a value which is independent of the initial percentage of believers. Thus the inability of the church to hold its own children in the faith will prevent it from converting the whole population over time. The result of the net balancing loop due to deaths and births is to lower the possible growth limit of the church.

The lower the conversion potential the lower the growth limit the church reaches in society, and the longer it takes to do so. Halving the potential number converted per believer per unit time results in a drastically slower growth. It also sees the believers' final share of the population drop from 84% to 68% for the case where no children are retained by the church. If the church cannot hold its own children the conversion potential becomes crucial. Indeed it is possible that the conversion potential could be so low that the church eventually becomes extinct.

Consider the case where the church is already 50% of the population, and is only able to hold 50% of its children. The church then requires a conversion potential of 1.4 just to stand still. Anything lower and the church will decline. This has been the pattern of church decline in Western Europe since 1900, where the failure to hold children has been a significant factor.

2.3 Reversion

2.3.1 The Reversion Process

The next assumption that needs to be challenged is that believers remain believers all their lifetime. Clearly some do renounce the faith and return to the world. This may be for a number of reasons:

- Physical persecution. At its most extreme believer's lives could be in danger, as frequently happened in the early church. Christians would be asked to swear allegiance to Caesar and curse Christ, or face death. Those who succumbed were no longer welcomed in the church. The fear of this test caused many others to renounce the faith also.
- Psychological persecution. Some believers give up the faith due to pressure of unconverted family or peers. The pressure may take the form of teasing or being shunned from normal social activities. The believer gives up the church to have an easier life.
- Some of the believers were not truly converted in the first place and give up the faith once it loses its initial attraction. The unbelieving world they left behind has proved more attractive to them.
- The believer may have fallen into sin and caused them to be to ashamed to be part of the church anymore.
- The believer may have been hurt by others in the church and it is now too painful for them to be part of the church with those who hurt them.

Thus believers only remain believers for a fixed length of time. This is an averaging effect. Many believers will remain believers all their lives, but some do not and return to the unbelieving world. This has the effect of reducing the *average* length of time a person remains a believer.

Can these people ever return to the church? In other words will a softening take place that allows them to be converted again. It will be assumed that hardened people only remain hardened for a fixed length of time, after which they are open to re-conversion with the same likelihood as any unbeliever. Thus they can be regarded as unbelievers.

Thus the outline model is given in figure 7. Reversion has introduced an additional balancing loop on believers, reducing further the target level for the church. However there is also an additional reinforcing loop as hardened people are re-cycled around to unbelievers again. Thus the target will be reduced less.

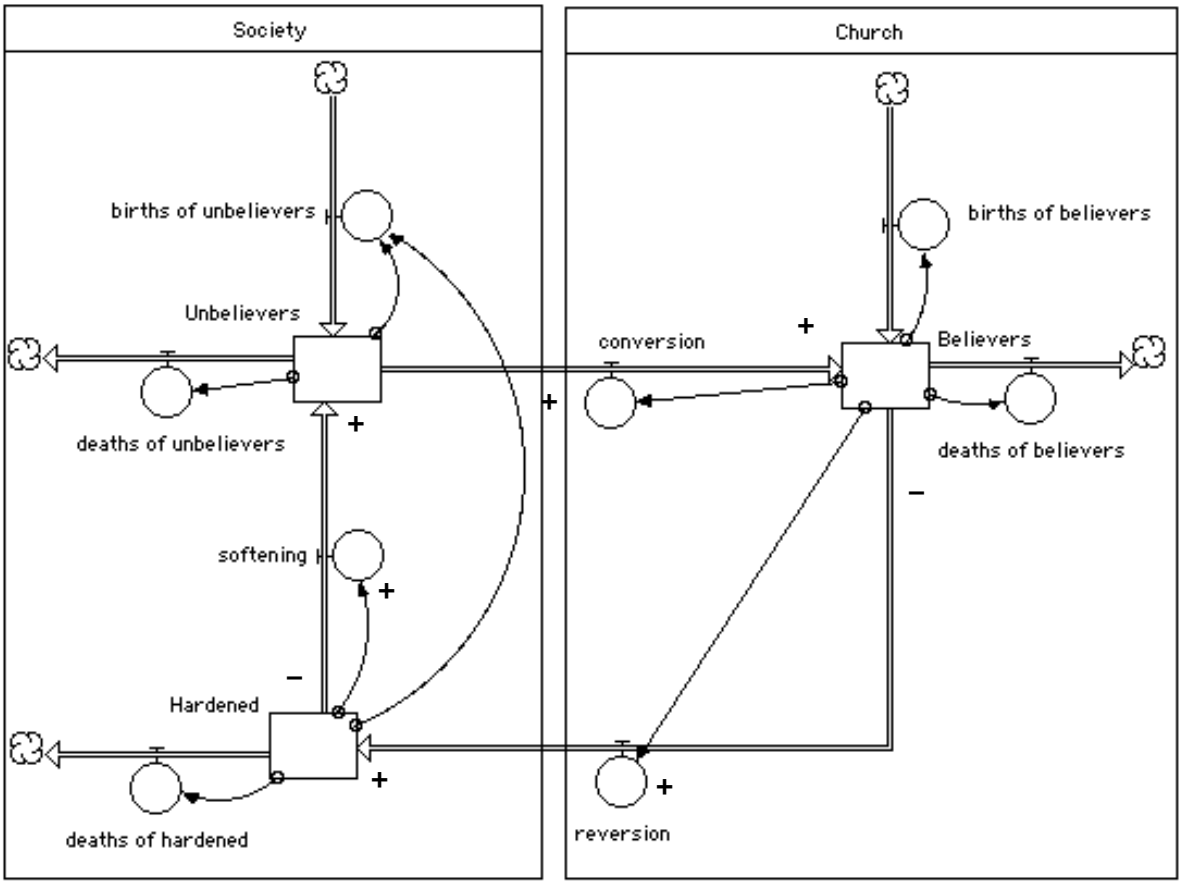

Fig. 7. Unlimited enthusiasm model with births, deaths and reversion with softening (conversion details missing)

2.3.2 Analysis - Short Term Behaviour

In the short term births and deaths can be ignored. Assume no softening on this time-scale. Thus the model is effectively the epidemic model where the susceptibles are the unbelievers, the infected are the believers and the removed are those hardened to conversion. Structurally this is the same as the model used in Hayward (1999) with the two main differences in that the middle category, the infected, constitutes the whole church and the final category, the removed, are people outside the church.

In the epidemic model the infected category always dies away leaving only the susceptible and the removed. Thus the church dies away after an initial growth, leaving some, but not all

of society hardened to conversion (figure 8). Clearly this is an unrealistic result as a time-scale has been chosen so that births and deaths can be ignored.

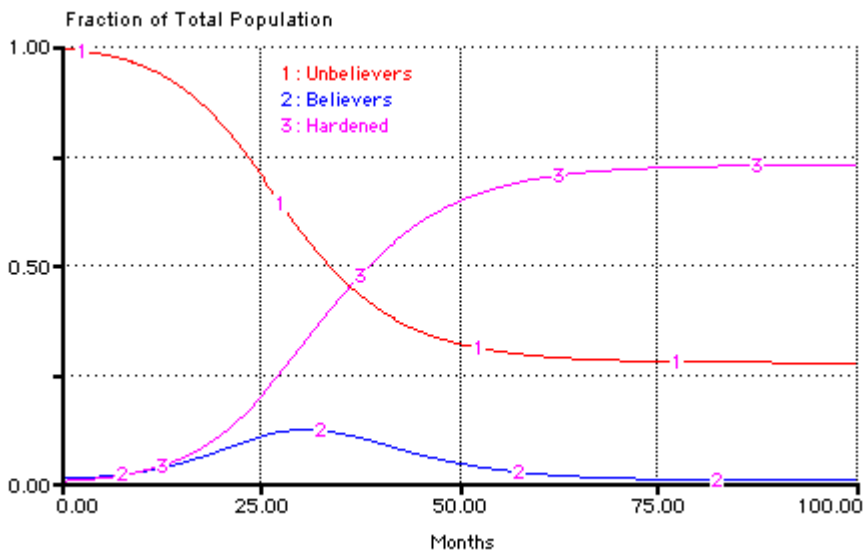

Fig. 8. Growth of church due to conversions and reversion at rate of 3% with no births and deaths

However it is a good model of short term fashion or behavioural patterns where there is no time to pass them onto children, or where children would have no desire to copy adults, or where they have been deliberately excluded from exposure to the behaviour. Many sects or cults follow this pattern and die out due to a failure to recruit enough to balance out those they lose.

The church itself has had such short-term behavioural patterns. One such example was an early charismatic movement in the UK under the leadership of a Presbyterian minister Edward Irving in the 1820's (Dallimore 1983). For a brief period a number of people exhibited charismatic behaviour. In this application the "unbelievers" are church people and the "believers" are those with the behaviour. The movement eventually burned out, not affecting the wider church or the later Pentecostalism. A church of such people did remain, but only a shadow of its former self and with little interest in recruitment due to its belief in the immanent end of the world. These are the equivalent of the hardened. Many adventist sects follow a similar growth pattern and later become extinct.

2.3.3 Analysis - Long Term Behaviour

If births and deaths are included a more realistic picture for the growth of the church is achieved. If the person is permanently hardened and never open to being converted back into the church then the tendency is for the church to make part of society hardened to the faith. Figure 9 is typical. Like the cases without reversion the numbers in the church level out to a fixed value, often declining to it after an initial overshoot depending on its initial percentage in society. Thus reversion, like births and deaths, causes the church not to convert the whole of society even when new unbelievers open to conversion are being born. However the church does not die away as the pool of unbelievers is being replenished by births.

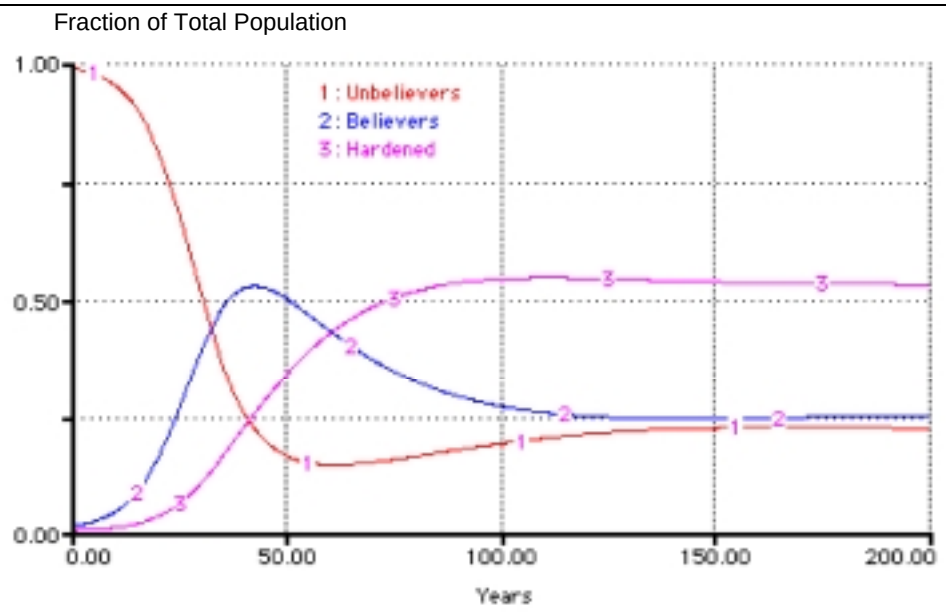

Fig. 9. Growth of church due to conversions and reversion at rate of 3%. Fraction born as believers is zero and potential number converted per person per unit time = 0.2

Adjusting the conversion rate or the fraction who are born believers makes little difference to the final percentage in the church, or to the time-scale to reach stability, although it has a bigger effect on the proportion of society hardened to conversion. The main effect on church numbers comes from adjusting the reversion rate. This rate of loss is therefore crucial for the long-term success of the church.

The reversion rate in figure 9 was chosen at 3%. This means that the average length of stay in the church is around 30 years. This explains why it takes at least double that figure for the numbers to stabilise. Of course this average is made up of a small number of people who stay much shorter than this and many who never leave the church at all.

Keeping the same parameters as figure 9 and introducing a softening rate of 1% sees a considerable improvement in the final value of the church of 35% from 25% without softening (figure 10). Increasing the softening rate further sees substantial improvements in the churches numbers e.g. a softening rate of 6% sees the church up to 56%. Thus a church which is losing people back to the world can make considerable improvements in its long term prospects if it seriously considers how to win back those people, and makes the effort to keep the dialogue open.

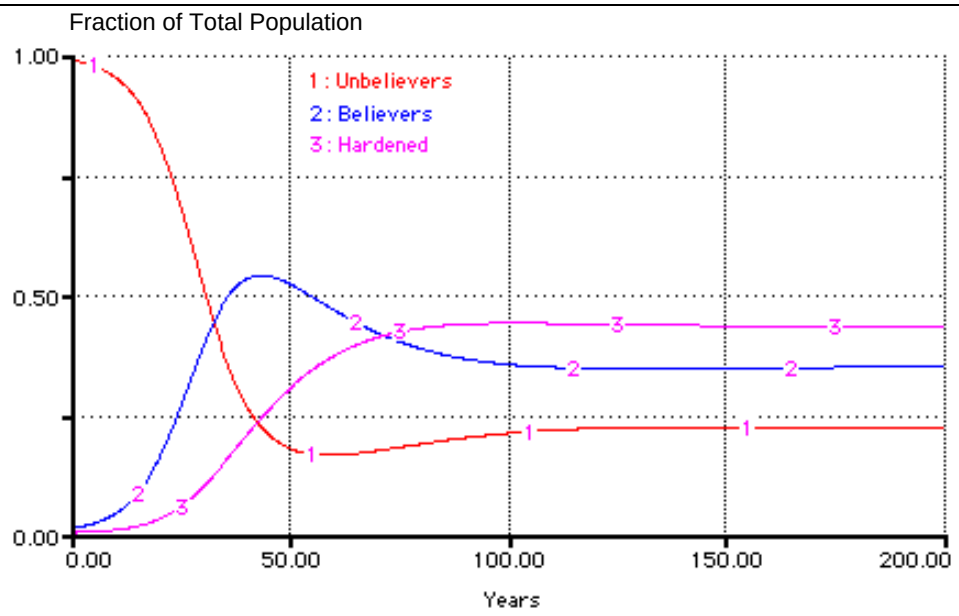

Fig. 10. Growth of church due to conversions, reversion at rate of 3% and a softening rate of 1%. Fraction born as believers is zero and number converted per person per unit time = 0.2

Notice also that the peak of the growth without softening (figure 9) is more or less the same as with softening (figure 10). Thus there is a temptation for the church in a successful period to ignore reversion because it has little short term effect on numbers. However it is the long term numbers that reversion effects. Notice in figure 9 the decline is much greater.

2.3.5 Church's Prospects with No Conversion

Clearly with no conversions taking place then growth of the church is not possible unless the church has a higher birth rate than surrounding society. Of course if there are no reversions and all the children remain in the church then the church will not decline. However what if there is reversion, could the church continue to maintain itself with a higher birth rate?

A typical situation is given in figure 11. The church can indeed maintain itself, but only at the expense of unbelievers growing. Although it is possible for a church to grow in proportion to society by having a higher birth rate, once even a moderate amount of reversion takes place a substantially higher birth rate is needed to maintain the church's proportion in society. Trying to counterbalance reversion by the birth rate is highly unstable. Small changes in birth rate can make the difference between survival and decline. Believers are subject purely to birth and death processes which either grow exponentially or decline to zero unless they just balance out. The conversion loop, which gave the stability by setting the target at or below the level of the total population, is now missing.

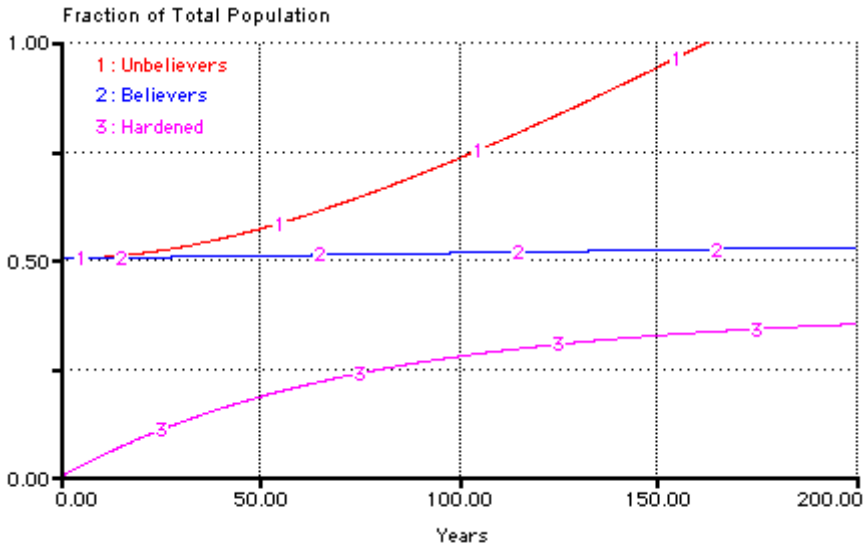

Fig. 11. Church growth model with no conversions, a reversion rate of 1%, and a birth rate of believers 70% larger than the rest of society.

The church losing a fraction of its children produces similar effects. Thus the effects of reversion, or losing children, can only be safely counteracted by conversion from the unbelieving pool. The prospects for any group that does not recruit is bleak unless it is so self-contained that virtually no-one is lost and they consistently have larger than average families.

3 Limited Enthusiasm Church Growth Model

3.1 Limited Enthusiasm Without Births, Deaths and Reversion

3.1.1 Rationale for the limited Enthusiasm Church Growth Model

From the results of chapter 2 it is clear that growth in the unlimited enthusiasm church growth model is only limited by the failure of the church to hold all its own young people and reversion from the church. Even in these cases *the church numbers levelled out to a fixed value*. Although this can be regarded as a good model of the *growth* of the church, particularly in periods of revival, it doesn't model the *decline* of the church. Currently the Christian church in Western Europe is marked by decline and not growth which may well lead to its extinction from large parts of that area within a generation or so. The unlimited enthusiasm model has depended on an unrealistic assumption that believers continue to recruit in the same way indefinitely

Instead it is found that believers stop recruiting for a number of reasons:

1. The believers have been recruiting through their network of friends and relatives which is now exhausted. There are three scenarios:

   - the people in this network have become believers themselves;
   - or they have become immune to any further pressure to join the church;

- or they have ceased to have meaningful contact with the believer. Many new converts find after a year or so that they have a new set of friends in the church and their old unbelieving set have drifted away. Often the new convert does this subconsciously because being part of the church means taking on a new set of values leaving them uncomfortable with the values of their old friends.

2. Churches do not just recruit or evangelise. After a while new converts find other work to do within the church and spend less time on recruitment activities.

3. In periods of intense growth the pastoral demands of dealing with new converts prevent ministers from spending as much time on evangelism as they might like, and thus their recruitment potential drops.

4. Often believers run out of enthusiasm for recruitment and settle into a more subdued version of belief where the zeal to see new converts has declined to the point of inactivity. Again there are a number of scenarios behind this:

   - the believer has forgotten why they were converted from unbelief to belief. They now have no desire to see others converted;

   - often the believers gain status within the church and lose the real reasons why they joined in the first place. Any enthusiasm they now have is centred on their own advancement;

   - the believers may find the church so enjoyable that their enthusiasm is for their own experience of it rather than to see others converted;

   - it may be that the church has not lived up to expectation and the believer has lost enthusiasm for anything to do with the beliefs. Instead they have settled into a nominal church life.

   Many of these reasons are summed up in Wesley's Law of the decline of pure religion. "Taking up the religion has produced benefits which makes missionary zeal too costly to engage in" (Kelly 1986)

Thus it is assumed that a believer's enthusiasm, or recruitment potential, is limited in time. This immediately leads to two categories of believers, active believers and inactive ones. The active believers are active in recruitment and could be called enthusiasts where it is understood that their enthusiasm includes zeal to see others converted and behaviour that actively does something about it. This leads to the limited enthusiasm model of church growth. The dynamics of the growth of the church is driven by these enthusiasts, who may be dedicated evangelists or lay-people with a zeal for spreading the faith.

It should be stressed that it is purely the recruitment potential of the enthusiast that is limited. As there are so many ways in which this may happen the inactive believers may still include people who display enthusiasm for other aspects of the faith. Indeed this is characteristic of times of revival where believers have a heightened experience of what it means to be a believer and thus a much larger desire to see others so converted. This desire does not last long before they move back to the level of enthusiasm for conversion that they had before, but it is sufficient to cause a period of rapid growth in the church.

Thus inactive believers are only comparatively inactive compared to the believers. They may indeed have some recruitment potential, but much less than the enthusiasts. For the purposes of this model it will be assumed that inactive believers play no part in recruitment.

3.1.2 Construction of Limited Enthusiasm Model

It will be further assumed that all new converts will be active believers until one of the above processes makes them inactive. Also it will be assumed that there is no mechanism for making inactive believers enthusiasts again, so once inactive they will never become active in recruitment again.

This leads to a three compartment model where unbelievers get converted by active believers and become, active in recruitment themselves. After a time active believers become inactive (see figure 12). This is the model described mathematically in Hayward 1999, and used by Coleman 1964 and Bartholomew 1983 for the spread of rumours.

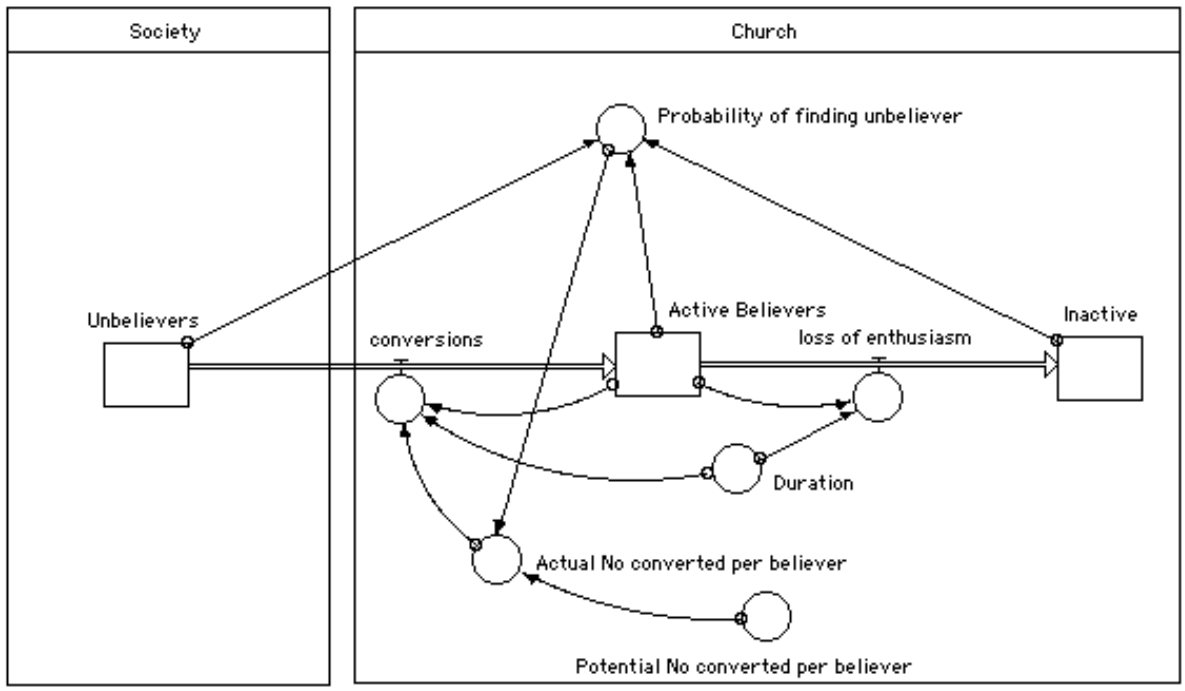

Fig. 12. Limited enthusiasm church growth model with no births, deaths or reversion

As in the unlimited enthusiasm model, the number of conversions depends on both the number of unbelievers and active believers. Because enthusiasm is limited it is now more convenient to let the conversion parameter be the potential number converted per believer during their enthusiastic phase *given* all their contacts are unbelievers. Clearly the actual number will be less when the proportions in church compared to society gets bigger, as in the unlimited enthusiasm model.

However now the number of conversions per unit time (*conversions*) will also depend on the length of time spent in the active category. Thus if every enthusiast converts two others during their enthusiastic phase the number of conversions in one year will depend on how long they are enthusiastic. If it takes two years rather than one the dynamics will be slowed down.

In Hayward 1999 it was shown that this approach could model the case where the number of potential converts went up if there were more people (crowd model) and where the number of potential converts were fixed regardless of population size (fixed contacts model). This was providing the total population remained constant.

Thus the number of conversions per unit time are:

Conversions = Actual number converted per believer X Active Believers / Duration

A new parameter called *Duration* is now introduced which effects the conversion rate. *Duration* also determines the rate of transfer from active believers to the inactive believers, which is assumed to be a draining process.

This model is the classic general epidemic model which has been extensively studied and developed (Bailey 1975, Anderson and May 1987). The mathematical foundations of this model, and further details of its relationship to church growth, are given in Hayward 1999.

3.1.3 Analysis

The active believers are now subject to another balancing loop, the draining process to the inactive believers, compared with the situation in figure 2. However this balancing loop includes a negative flow, so that not only is its level limited but will now actually be reduced to a target level. As this is a straight draining process the target is zero and the active believers eventually decline and disappear after an initial growth. This is the standard behaviour of the epidemic model where the active believers are like those infected with the disease. The inactive believers are like those who have been "cured" from the disease, or have died, and are no longer open to infection, or able to infect others. Figure 13 shows a typical pattern of growth.

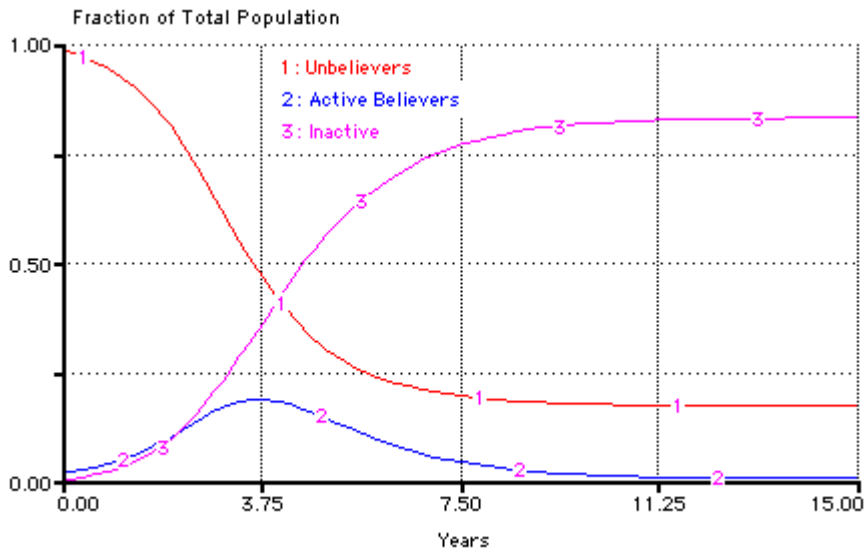

Fig. 13. Limited enthusiasm with no births, deaths or reversion. Enthusiastic phase is 1 year and the number converted per believer is 2

Clearly the numbers in the total church, eventually reflected by just the number of inactives, is limited and the church has failed to convert the whole population. This was the result discovered by Kermack and McKendrick (1927) where they showed that even in an epidemic the

infection didn't spread through the whole population. It burned itself out due to a lack of infected people who had less and less contact with those susceptible to the disease and more with those already immune. In the church growth case the growth has run out due to a lack of enthusiasts.

It is this type of sudden growth behaviour which characterises times of religious revival both at the local level, and at a national or international level. Examples of such local growth in the Christian church are well documented: Northampton Massachusetts in the 1730's (Edwards 1965); Nagaland North East India 1976 (Orr 2000) and more recently Pensecola Florida from 1995 onwards. Examples of such national growth include the First Great Awakening 18th century USA and UK (Edwards 1990), Second Great Awakening Early 19th century USA. Much faster revivals occurred in the USA (1858) and then Wales, Scotland and Northern Ireland in 1859 and also Wales in 1904-5. A much longer revival in the twentieth century has been the growth of Pentecostalism especially in South and Latin America.

Apart from those revivals still continuing, all show the characteristic rapid rise in total church numbers with the growth eventually burning itself out. Of course church data doesn't record the number of active believers. However the model was applied in Hayward 1999 to church membership data for the Welsh revival of 1904-5, where it was shown that the potential number converted per active believer was about 2.02 with the duration of the enthusiastic phase about 1 week. Clearly these are average values, not true of every enthusiast in the revival.

In fact extending the enthusiastic period does not make any difference to the final numbers in the church in this model, it simply takes longer for the growth to occur. The key parameter is the potential number converted per (active) believer. Decreasing this will result in substantially less conversions. Indeed, if this had been lower than 2, then no revival would have taken place. It is remarkable how such a small change in the effectiveness of those who recruit makes such a large difference to the growth of the church.

The potential number of conversion per active believer is the parameter that governs the *threshold* of the epidemic type growth. According to epidemic theory (Bailey 1975, Anderson and May 1987, Hayward 1999 equation 23) if the number of unbelievers times the potential number of conversions per active believer is above one then the epidemic or revival will occur. If it is below one then there will be no such growth.

3.1.4 Not All Converts Become Enthusiasts

One criticism of the idealistic limited enthusiasm model is that all converts become enthusiasts themselves. Even in times of religious revival the change in a person's life may not extend to zeal for recruitment. Indeed some new converts may come from families where most are already believers and thus have few unbelievers they can make contact with. Thus not all new converts are enthusiasts. This leads to an extra parameter to determine the proportion of converts who become active believers. The dynamical model is now modified as in figure 14.

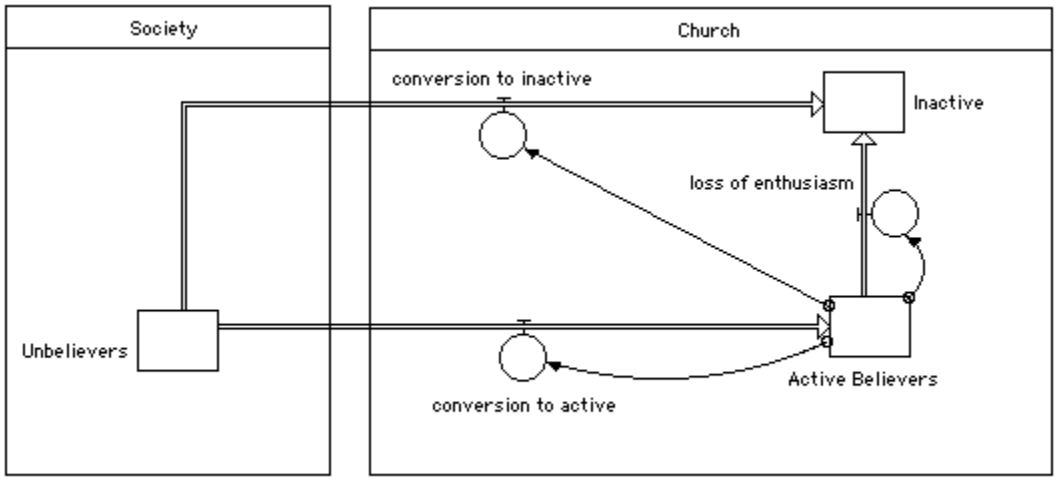

Fig. 14. Limited enthusiasm model where not all the converts become enthusiasts

It is now possible to fit the data from the 1904-5 Welsh revival to this new model where not all the converts become active. In 1904 the combined total membership for Welsh churches stood at 48.94% of the total population (Hayward 1999 & 2000), and rose to 53.43% by the end of 1905. The bulk of the converts came in a period of about 12 months.

Now assume only 10% of converts became active believers, the results of the simulation yield a duration for the enthusiastic phase in a believer of about 1 month and the number converted per active believer at 18.3. Compared with the model where all converts became enthusiasts the enthusiastic phase is four times longer and each enthusiast has nine times as many converts. Thus to explain that the revival was spread by a smaller number of people requires a much larger effectiveness on the part of the enthusiasts. If only 1% of converts become enthusiasts then each enthusiast needs to make around 100 converts in 4 months!

It is more likely that many converts became enthusiasts and spread news of the revival to a smaller number of people. After hearing that news the potential converts came to a place where revival was happening and some became converted. Note it was the *spreader of the news* who was the enthusiast rather than the evangelist who spoke in the revival meeting and thus their action which was the key to the dynamics of the growth of the church.

3.2 Limited Enthusiasm With Births, Deaths and Reversion

3.2.1 Construction of Model

It is now possible to include the effects of births, deaths and reversion in the limited enthusiasm model. There are now 3 processes that will limit the growth of the church:

- the limited enthusiastic period of believers;
- reversion from the church to the world;
- inability of the church to keep all its children in the faith.

Now there are two categories of believers some assumptions need to be made with regard to reversion. It is assumed that those active believers who revert and become hardened don't do so directly. Instead they become inactive believers first.

Again with births a decision has to be made whether the children of active believers become active themselves, or are inactive. A parameter is introduced to control what proportion of active believers are born believers and the proportion of these who are born active. It may well be that active believers may hold more of their children in the faith than inactive ones because generally they have more enthusiasm for the beliefs themselves.

The basic stocks and flows are given in figure 15. The conversion process follows figure 12 for recruitment to both active and inactive believers. Births, deaths, reversion and softening processes follow figures 4, 5 and 7.

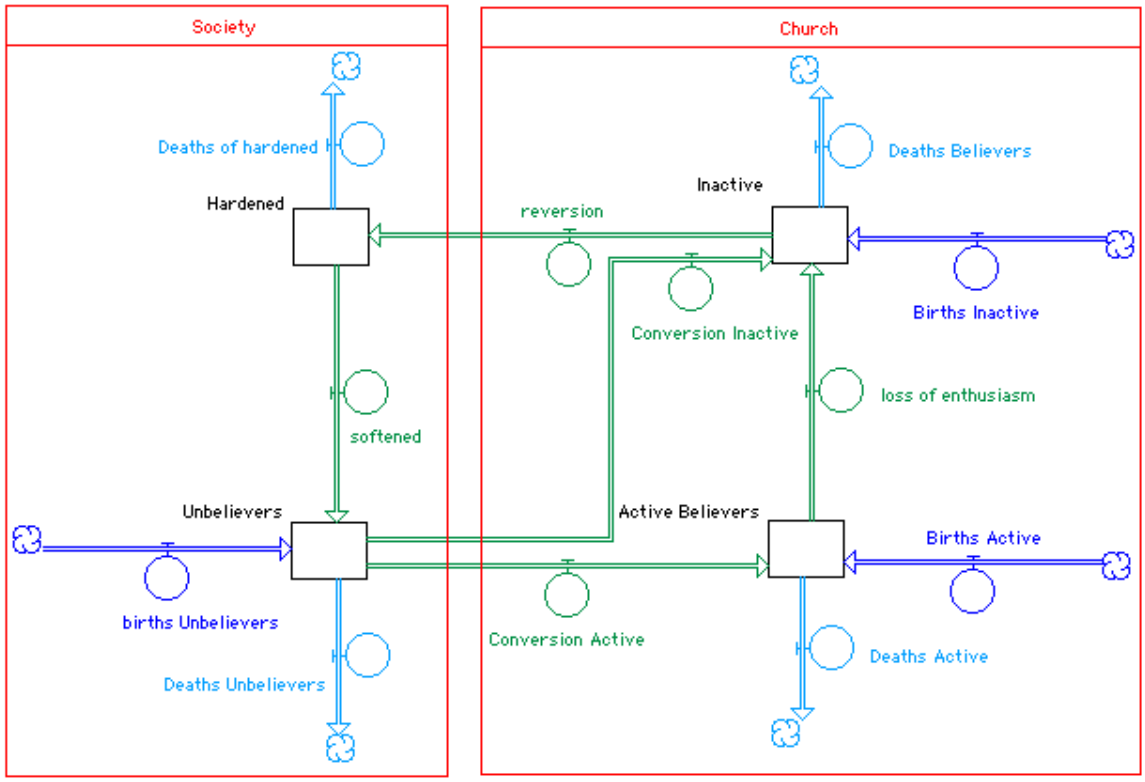

Fig. 15. Outline of limited enthusiasm conversion model with births, deaths and reversion. Conversion details are suppressed but are similar to figure12.

3.2.2 General Comments

Simulations show that a steady state situation, where the church settles to a fixed percentage of society, is possible, with a typically small percentage of the church being enthusiasts or believers active in recruitment. Unlike the church growth model of Hayward (1999) these enthusiasts do not die out but sustain themselves, and the rest of the church, at fixed levels. A small increase in their recruitment potential can see a substantial rise in the number in the church. Typically the numbers oscillate for 100-200 years before settling to a new level. Thus even with no change in parameters, stability in numbers can take a long time to achieve

The steady state values correspond, more or less, to the threshold of the epidemic outlined earlier. However in this case if the potential number of conversion is above the threshold, then the church survives with numbers at stable values largely determine by that conversion potential. However if it is below the threshold the church will eventually decline to extinction. The potential number of converts per active believer is crucial for the church's survival

The full model is extensively analysed in Hayward (2000). Here applications will be limited to two cases from the last 100 hundred years: the Christian church in Western Europe and also in South America.

3.2.3 Church Decline in Western Europe

At the beginning of the 1900's the church in many European countries accounted for about half the population. However enthusiasm was noticeably running out, especially with a tide of disbelief and liberalism within the church's own ranks. A simulation of the subsequent decline appears in figure 16, where the parameters:

potential number converted per active believer = 2.4
duration of enthusiastic phase = 4 years

were estimated by matching the graph of the total number in the church to data for the last one hundred years (UK data was used Brierley 1999a).

Other parameters estimated by recent data or local anecdotal evidence:

reversion rate = 0.016, softening rate = 0.5, fraction made active = 0.5,
fraction inactive born unbeliever = 0.75, fraction active born unbeliever = 0,
fraction active born believer and active = 0.5

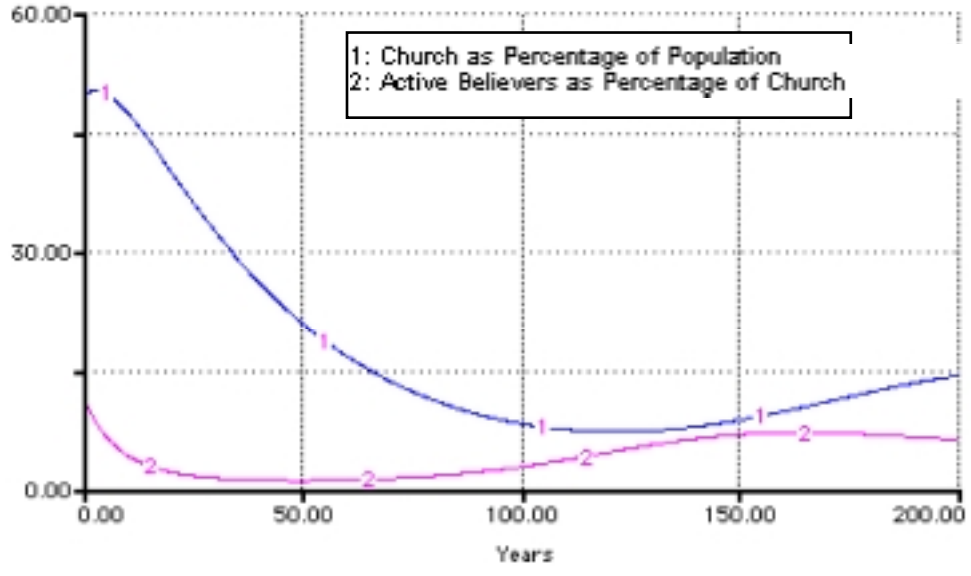

Fig. 16 Typical church decline in Western Europe from 1900.

Note that the number of enthusiasts in this model has been rising for the last 50 years of the 20th century. In reality there has been a rise in the most enthusiastic part of the church, the

evangelical and charismatic parts. These are the section of the church that recruit the most. If this model is close to the truth then the church will begin to start growing again in about 30 years due to the increasing number of enthusiasts. This growth is without any change in the value of the parameters and is a generational effect due to child losses and reversion achieving their true level rather than a true revival. There is a long-term damped oscillation to a fixed value. Eventually it could recover from its current low of 8% to about 14% of the total population at the end of the 21st century.

What can be done within the church to improve the growth by changes made now? Changing the softening rate has little effect. However if reversion is switched off the final value of 14% becomes 16%. It becomes 18% if all the children are retained and 20% if both effects are combined. Clearly tackling loses makes some significant improvements.

The dramatic effects come from improving the recruitment to the church. If the potential number converted per active believer goes from 2.4 to 3 the percentage in the year 2060 is now 30%, see figure 17. Indeed the same improvement can be made by making 60% of the new converts enthusiasts rather than just 50%. Now the oscillations are taking longer to settle down.

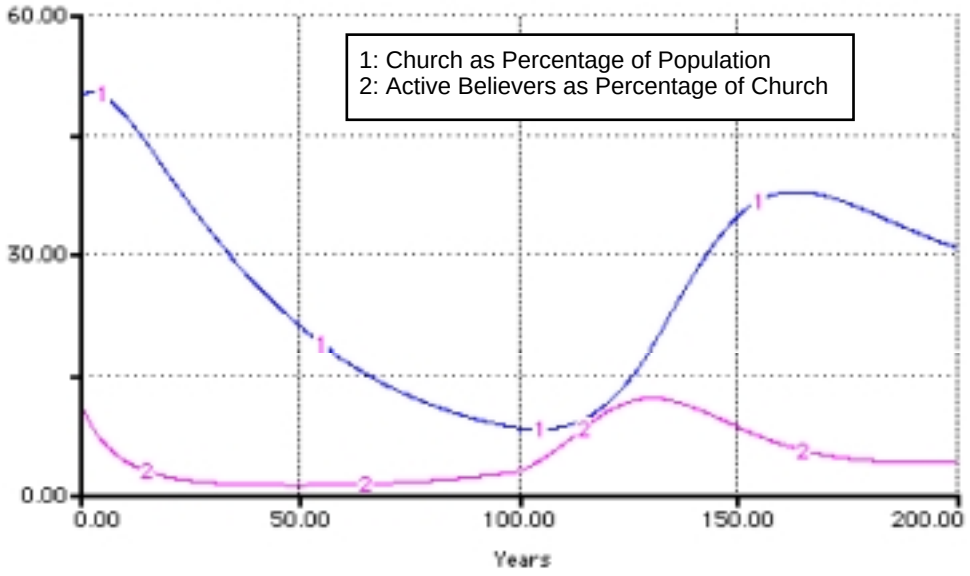

Fig. 17. Typical church decline in Western Europe 1900-2000 followed by increasing the conversion potential 2000-2100

Also of significance is the lag between the total number in the church and the number of enthusiasts. The number of enthusiasts starts to wane long before the church does. If the number of enthusiasts could be measured then early warnings of problems within the church could be given.

3.2.4 Church Growth in South America

The Protestant Christian church in South America has seen explosive growth especially during the 1970's and 1980's (Brierley 1999b). This has been largely the result of the activity of

Pentecostal churches which display a high degree of enthusiasm. A typical simulation is given in figure 18, where:

potential number converted per active believer = 3.3
duration of enthusiastic phase = 10 years

have been adjusted to fit typical South American church membership data. Other parameters are kept the same as in the European case.

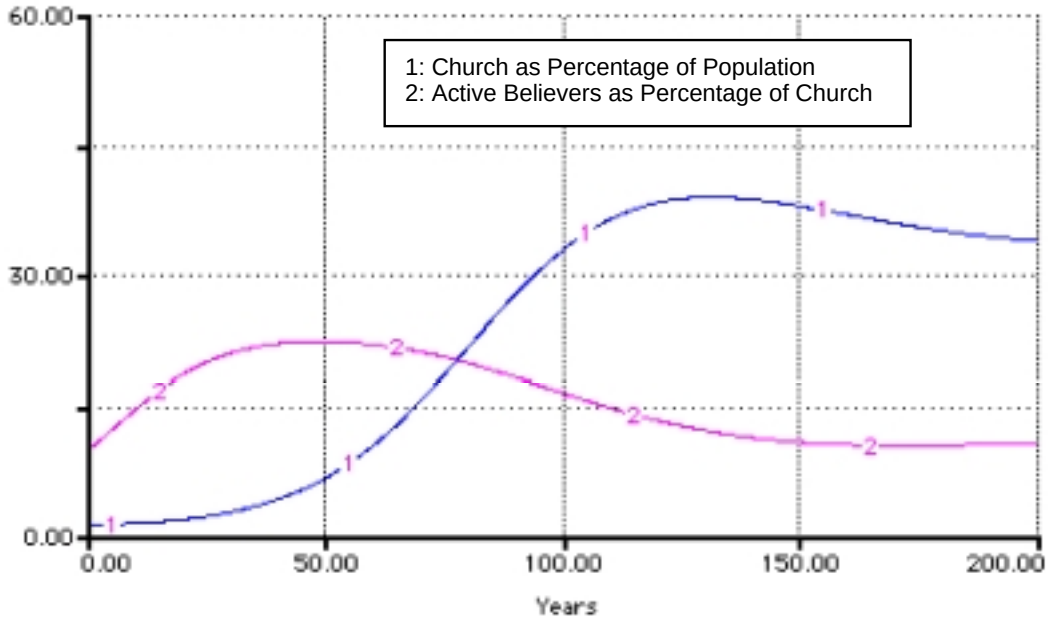

Fig. 18. Typical church growth in South America 1900-2100

Clearly the percentage of enthusiasts is now past its peak leading to a levelling off and slight decline for the total church in the next 50 years. If this situation is true then the South American churches should be seeing a rise in the level of nominalism in the church. If so tackling this nominalism could prevent the church's future decline. If the church wants to see growth beyond these projected levels it must improve its conversion rate. It cannot expect to see the whole of the population converted on its current levels of conversion.

4 Conclusion

4.1 Main Conclusions

- Realistic patterns of growth are seen when the recruitment to the church is driven by enthusiasts responsible for the conversions.
- If all the church are such enthusiasts, and they are able to keep all their members, and bring all their children into the faith, then the whole population gets converted.
- If a church loses some of its children, or members, then even if they are open to reconversion, the church does not convert the whole of society.

- If not all the church are enthusiasts, either because they have lost their enthusiasm, or never had it in the first place, then the church fails to convert the whole of society.
- If the church survives it always tends to fixed stable values as long as parameters do not change.
- If the conversion potential of the enthusiasts is not high enough compared to its losses the church will eventually become extinct.
- In the short term the number of enthusiasts can be become extinct as they increasingly fail to reach a shrinking pool of unbelievers. This occurs before all the unbelievers get converted.
- The church may rise to a high percentage before the effects of reversion cause it to stabilise at a lower value. Thus success in the church may initially mask the long term damage that reversion will cause.

4.2 Further Work

- The models need to be applied to more situations involving churches and others subcultures. Applications to the growth of drug use may be particularly relevant
- In particular the limited enthusiasm model needs to be investigated for non-religious subcultures. Recruitment to such groups as vegetarians is passive rather than active, i.e. by people observing their lifestyle In this case "conversion" will not depend on a believer's enthusiasm. Thus the limited enthusiasm model may not be appropriate.
- In the case of lifestyle and youth subcultures the effect of advertising, which does not depend on contact, needs to be built in.
- A mechanism is needed to allow inactive believers to be "re-infected" by active believers and thus have their enthusiasm restored.

5 Acknowledgements

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